Philippine
THE MINING BUREAU.

BULLETIN No. 1.

PLATINUM AND ASSOCIATED RARE METALS IN PLACER FORMATIONS.

INFORMATION FOR PROSPECTORS AND PLACER MINERS

BY

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PLATINUM AND ASSOCIATED RARE METALS IN PLACER FORMATION.

By H. D. McCASKEY, B. S.

It is perhaps more than a possibility that among the river gravels and sands and the beaches of the Philippines there will be found platinum and the associated metals, whether occurring with gold or not. In the hope that these rare and valuable metals may be eventually discovered and worked with profit in these islands, and with the belief that information bearing upon the subject will be of interest and value to placer miners, both present and prospective, this bulletin is now published.

We have prepared these notes for those whose inquiries may be partially or wholly met by what is briefly presented here.

THE PLATINUM METALS.

The metals most frequently found with platinum, not including gold, are iridium, osmium, palladium, rhodium, and ruthenium. With these metals also frequently occur chromite, corundum, zircons, rubies, and diamonds. These metals are all rare, occurring in very small quantities in the sands and gravels. Placer deposits supposed to contain any or all of them should be carefully sampled and concentrated, and the concentrates should be sent to some firm interested in the purchase of them, for analysis and report.

The world's supply of these metals is extremely small and, as there is a constantly increasing demand for platinum and osmium, and as the others of the group may find a market at any time, the most practical results will be obtained by miners if they send their concentrated samples direct to those interested in the extraction and production of these particular metals. The only firm at present known to this Bureau which has offered to assist in the discovery and determination of these metals in the Philippines is that having the title of The Waratah Mineral Company Ltd., represented by Mr. W. P. Butler, of 140 Ellis street, San Francisco, Cal. A letter from Mr. Butler, sent recently to Governor Taft and referred to this Bureau, contains some of the information here published.

VALUES PER TROY OUNCE.

Platinum	**$14.50@$16.00**
Iridium (in Germany)	**37.00**
Osmium (in Germany)	**29.55**

These values vary, of course, and are here given only as guides. Pure platinum may be safely estimated at the value of pure gold, with a ten-

dency to rise above it. The prices of iridium and osmium, as given above, are for the refined metals at the makers' works in Germany. Iridosmine, the compound commonly furnishing the supply of osmium for the market, is worth, unrefined, from $6 to $10 per ounce, according to quality. Crude platinum, as found in the mines, is worth about 75 per cent of the value of pure gold or pure platinum.

MINERALOGICAL CHARACTERISTICS.

PLATINUM (*Platina Sp.*)

This metal crystallizes in the isometric system, though rarely crystalline. It usually occurs in grains and scales, and sometimes in nuggets. It has no cleavage and has a hackly fracture. It is malleable and ductile, with a hardness of 4 to 4.5 and a specific gravity of 16 to 19 when native and 21 to 22 when pure. It is, therefore, heavier than gold. It has a metallic lustre and a whitish steel-gray color. When scratched upon a piece of unglazed porcelain it leaves a streak of the same color. It is frequently alloyed with iron (which sometimes gives it magnetic properties), with iridium, osmium, and with other metals of the group.

Platinum is infusible before the hottest blow-pipe flame and is soluble only in heated nitro-hydrochloric acid. It is found in placers in Borneo, San Domingo, Ireland, Honduras, New Zealand, New South Wales, California, Canada, British Columbia, and Alaska. According to Prof. J. F. Kemp, of Columbia University, samples of rock from Leavenworth, Washington, have recently been found to contain three-eighths of an ounce of platinum to the ton, and the finer material from the same locality contains one-half ounce to the ton; and it has also recently been found in vein formation in the copper mines of the Medicine Bow Mountains in Wyoming. It occurs sometimes, though rarely, in quartz lodes, and has been found in the feldspathic and serpentine rocks.

IRIDIUM.

Although it is neither likely nor important that this mineral, or the ones following, be distinguished from platinum by the placer miner, a few brief notes will be here inserted.

Iridium crystallizes, though rarely, in the isometric system, in cubes. It is generally found in small, angular grains. It has an indistinct cubic cleavage and a hackly fracture, and it is somewhat malleable. It has a hardness of 6-7, or nearly that of quartz crystal. Its specific gravity varies from 21 to 22, being, therefore, greater than that of either gold or platinum. Its luster is metallic and its color a silver white, with a tinge of yellow on the surface, and gray on fracture. It is opaque.

Iridium is found alloyed with platinum and the other allied metals and it occurs with platinum in the Urals and in Brazil, and with gold in California. The unrefined product of the placers sometimes carries as much as 55 per cent of platinum, 4 per cent of iron and 3 per cent of copper.

IRIDOSMINE. (Also called *osmiridium* and *iridosmium.*)

This ore of iridium and osmium is a combination of these two metals

in varying proportions, with some rhodium, platinum, ruthenium, and small amounts of copper and iron. It crystallizes rarely in the rhombohedral system in flat hexagonal prisms. It is usually found in irregular flattened grains. Its basal cleavage is perfect. It is slightly malleable to nearly brittle. Its hardness is between 6 and 7 and its specific gravity betweeen 19.3 and 21.1. Its color is tin-white to light steel gray. Its lustre is metallic and it is opaque. At a high temperature iridosmine gives out osmium when carrying less than 30 per cent of iridium and fails in this reaction when containing more than 40 per cent of iridium. With niter the odor of osmium is detected. The vapor of the tetroxide, called osmic acid, has an intolerable, pungent odor, attacks the eyes and is exceedingly poisonous. The mass obtained by treating iridosmine with niter is soluble in water and a green precipitate is thrown down from this solution by nitric acid. Iridosmine occurs with platinum in South America and in the Ural Mountains, and it is found in auriferous and other drift deposits in New South Wales. It is rather abundant in the gold-beach sands of Northern California in small, bright, lead-colored scales, occasionally six-sided, and it is found in traces in the gold washings of Canada.

USEFUL TESTS.

Although the prospector in the field may never avail himself of any but the rudest tests, such as examination of color, hardness, malleability, and specific gravity, it is barely possible that means may be found by some to do rough qualitative work in the office, and for them a few tests for platinum and other metals of the group will be briefly outlined.

PLATINUM.

The following characteristics will greatly assist in the identification of platinum: Color, high specific gravity, infusibility, and insolubility in any single acid. For a more definite test the metal may be fused before the blow-pipe in the form of fine filings on charcoal with test lead and some borax. The metallic globule, now an alloy of platinum and associated metals, with lead, may be freed from slag by hammering upon an anvil. It may now be cupelled or dissolved. If cupelled on bone ash before the oxidizing flame of the blow-pipe, a brittle, infusible button will be obtained, without luster and containing lead. The latter may be removed by a second cupellation with gold, and the platinum metals may now be hammered thin, annealed, and dissolved in aqua regia. If not cupelled the original lead button containing the platinum metals may be treated with dilute nitric acid (1 of concentrated nitric to 2 of pure water), thus dissolving everything but platinum and gold. The residue should be filtered, washed, and ignited. In either case we are now ready for the treatment with aqua regia. The solution in a mixture of nitrohydrochloric acid (1 of nitric to 3 of hydrochloric, to be made up fresh whenever needed), can now be readily accomplished. To filter free from any black powder of iridium present, evaporate nearly to dryness at mod-

erate heat, add some hydrochloric acid and evaporate again. Add a little water and then enough ammonium chloride to convert all the platinum into ammonium platinic chloride, thrown down as a yellow precipitate. Evaporate nearly to dryness, carefully digest the residue with alcohol (80 per cent), filter and wash with alcohol until the filter no longer colors the wash alcohol. The precipitate ignited yields a gray platinum sponge. The gold may be precipitated from the filtrate by expelling the alcohol by heat and then adding a solution of ferrous sulphate. The precipitate may be fused into a gold button with borax. Platinum may rarely be mistaken by some for native silver, but it is much heavier, and it is not soluble in, nor affected by, nitric acid.

IRIDOSMINE.

This mineral is probably too hard to be mistaken for any other white metal. The powdered mineral in an open tube over a hot flame will give generally the osmic oxide with its characteristic odor, somewhat like that of bromine, and very poisonous. If, after the oxide is generated, the upper end of the tube be placed in the flame the osmic oxide will render the flame luminous from the reduction of the oxide and the glowing of the finely divided metal.

Iridium, and sometimes iridosmine, may be partially oxidized by fusing with sodium nitrate in a bulb tube. The fused mass, if boiled in aqua regia, should yield a deep red to reddish-black solution.

Thorough chemical analyses of the platinum metals are among the more difficult quantitative operations. Sands and concentrates, therefore, containing white metals more or less malleable, insoluble in single acids, and of specific gravity and concentrating behavior similar to those of gold, should be sent for report and best results to special firms interested in these particular products.

SUGGESTIONS FOR CONCENTRATING.

Platinum metals will not amalgamate with mercury without special treatment. To save them, concentrating appliances must be used, and these will also save most of the coated gold, not ordinarily subject to amalgamation. The riffles commonly used in gold-saving flumes can not retain any considerable portion of the platinum metals, as the greater values creep over the riffles and are lost.

A good concentrating surface is new Brussels or moquette carpeting. A better one, and more durable, is a special grade of cocoa matting, 27 inches wide. It should be worth about 50 cents gold per square yard by the roll.

An effective concentrating system for these rich gold and platinum-bearing sands consists merely of a box with cocoa matting laid upon the floor, a shallow tank and a wide-sawed board. The box should be 26½ inches wide, 12 feet long; should have 6-inch sides and should be given a grade of 1 in 6, or 24 inches to the 12 feet. The board should be about

the same dimensions with half the grade, that is, it should have a slope of 12 inches in 12 feet. The feathering caused by the sawing should be turned downward and not against the current.

The gravel and sand should first be screened through holes from one-eighth inch to one-quarter inch in diameter. The water should be clear and just enough to run the sands nicely on the box. The flow of water and sand can be regulated by strips placed across the head of the box, just above the matting, which is laid down to form the bottom surface of the box. Too great a flow should be avoided, as the resistance of the matting against the stream should act on all sand and water coming down. Every few days, or at intervals depending upon the richness of the material, the strip of matting should be taken up, after having been washed with a little clean water. The matting should then be thoroughly washed in a shallow tank, flapping it to and fro to clean it of concentrates and dirt. Much of the value will be found beneath the matting on the floor of the box. This should be scrubbed into the washing tank with a stiff scrubbing brush.

The material in the tank may be still more highly concentrated by running over the sawed board with just enough water to carry the dirt over the feathering. The metals will be caught, if the flow has been nicely regulated, and they may best be brushed into a pan like an ordinary dust pan. Too much care can not be used in this part of the concentration or the metals will run off the board. Careful regulation of the water and sands will save almost the entire value on the feathering.

The concentrates so obtained will contain the coated gold and the platinum metals. They should be placed in a pan with a strong solution of cyanide of potassium and enough mercury to amalgamate the gold. After a thorough stirring of from 15 to 30 minutes the cyanide of potassium will probably have so cleaned the gold that it will all have been amalgamated. The cyanide solution should now be poured off for future use. The platinum metals and the sand not yet separated will remain with the amalgam.

A third concentration may be effected by tipping the bucket or pan in which the amalgamation was made and running the sands over a second board, to be like the other and to be kept for just this stage of the work. A trickling stream should be used, with no more water than is required to run the concentrates over the board.

The platinum metals will be recognized now, as they are tin-white when clean. The grains or scales may be very small, in which case the metals will collect with the heavy sand and will lie in streaks of brown, brown-red or lead color, which creep along the board and are evidently very heavy. Great care should therefore be used in examining the tailings. A further final concentration may be made by boiling these richest concentrates in dilute nitric acid. The solution will carry away many impurities and none of the platinum metals.

These suggestions apply to small workings. In planning larger ones it will be found safer to increase the number of tables rather than their size. In case 12-foot boards can not be had shorter ones may be found almost as satisfactory. The grade should always be, for boards, about 1 in 12, and for boxes, about 1 to 6.

Do not crowd the tables; use sufficient grade and avoid too great a flow. The sands should be evenly spread in running down and the matting should not be allowed to dry while containing the concentrates. With care and skill these surfaces mentioned and these brief hints will be found valuable in saving the rich concentrates.

METALLURGY.

As the metallurgical treatment and refining of the platinum metals are special processes, requiring great skill and expense, no description of them will be given here. Those interested in pursuing the subject into the production of pure platinum, the platinum alloys, or the refined osmium and iridium metals, are referred to the standard metallurgical treatises. It is not thought that detailed information on this branch of the subject is either expected or desired in so brief a bulletin as this. Suffice it to add that rich concentrates of these metals can probably be shipped with profit from these islands to any platinum works now known.

MISCELLANEOUS.

Purified platinum is used now in electrical and laboratory apparatus, in dental practice, in jewelry, in making stills for sulphuric acid plants, in photography, and in making balance wheels for non-magnetic watches. The greatest part of the world's supply is obtained from the Russian placers of the Ural Mountains. Very little, comparatively, comes from other sources. According to the Mineral Industry for 1897, the Russian product in 1896 was 158,500 ounces.

Iridosmine, which is found only in fine grains, is used for pointing gold pens. The phosphide of iridium, from a fusion of iridosmine with phosphorus, is used for pointing tools and stylographic pens, for draw plates for gold and silver wire and for knife edges in the most delicate balances.

The platinum-iridium alloy is used for the standards of weights and measures.

H. D. McCaskey, B. S.,
Mining Engineer for the Mining Bureau.

REFERENCES.

Letter and circular from Mr. W. P. Butler to Governor Taft of August 3, 1901.
"Determinative Mineralogy and Blow-pipe Analysis," by Brush and Penfield.
"Mineralogy, Crystallography and Blow-pipe Analysis," by Moses and Parsons.
"Blow-pipe Analysis and Determinative Mineralogy," by Cornwall.
"Fowne's Elementary Chemistry," by Watts.
"A System of Mineralogy," by Jas. Dana.
"A Handbook of Metallurgy," by Schnabel.
Files of the Engineering and Mining Journal.

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THE MINING BUREAU.

BULLETIN No. 2.

COMPLETE LIST OF SPANISH MINING CLAIMS RECORDED IN THE MINING BUREAU.

COMPILED FROM THE RECORDS AND ARCHIVES

BY

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Chief of the Mining Bureau.

MANILA:
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CONTENTS.

COMPLETE LIST OF SPANISH MINING CLAIMS RECORDED IN THE MINING BUREAU.

Compiled by Mr. CHAS. H. BURRITT.

PREFACE.

The following data, compiled by Mr. Chas. H. Burritt, Chief of the Bureau, presents in tabular form a complete and accurate list of all mining claims as given in the Spanish records and archives of the Mining Bureau. It should be borne in mind in this connection that there are certain other outstanding claims, the number of which is not known, the procedures for the obtaining of titles to which had never reached the stage characterized by the receipt at the Bureau of the necessary papers from the respective provincial capitals. These claims belong properly to neither the first, second, nor third class as given below. Had the necessary papers reached the Mining Bureau in proper course, and had the titles not yet been issued at the time of the suspension of the work of the Inspección de Minas by reason of war, these would have been second-class claims.

The definitions of the three classes of claims as here given are set forth in the following paragraphs quoted from the annual report of Chas. H. Burritt, first lieutenant, Eleventh Cavalry, U. S. V., officer in charge of the Mining Bureau, to the Secretary of the Military Governor, dated August 15, 1900, and found upon page 7, Appendix II of the Annual Report of the Military Governor of the Philippine Islands to the Secretary of War for 1900:

"In his closing report on March 30, 1899, to the President of the Board of Liquidation, Luis Espina y Capo, engineer in charge of the Inspección General de Minas, divided the mining properties of alleged validity in the Philippine Archipelago into three classes, viz:

"1. Those for which concessions have been issued under royal decree, etc.

"2. Those in process of demarcation, as provided by the royal decrees, and the regulations thereunder, etc.

"3. Those for which petitions have been accepted with the deposit of fees waived in accordance with the order or decree of the Governor-General, dated May 4, 1898." (See Appendix II referred to above.)

It should be noted that *caliza marmorea* in the tables refers to limestone in some cases, but preferably to marble; that the existence of true granite in the Philippines has not yet been verified and is seriously doubted, and that the *granite* and *trachyte* of the Spanish classification of the building stones of the Province of Bataan are believed to be identical with the *andesites* of Mariveles; and finally, that *kaolin* given in the tables from Laguna has been found not to be true *kaolin*.

In the tables, similar marks, asterisks, etc., in connection with names of mines, indicate that in the same province mines similarly marked are identical in location.

H. D. McCaskey, B. S.,
Mining Engineer and Acting Chief of the Mining Bureau.

The Mining Bureau,
Manila, October, 1902.

TABLE I.—*Recapitulation of Spanish mining claims (first, second, and third class), arranged by provinces.*

Provinces.	Minerals.	Number of claims.	Superficial surface.
			Square meters.
Ambos Camarines	Gold, coal, copper, and iron	718	54,886,070.95
Bataan	Caliza marmorea, granite, and trachyte	7	140,000
Benguet	Gold	172	10,320,000
Bontoc	Gold	2	120,000
Bulacan	Iron	9	1,137,571.09
Cagayan de Misamis	Gold	246	14,760,000
Cebu	Coal, caliza marmorea, petroleum, and guano.	276	41,010,000
Infanta	Coal	4	600,000
Laguna	Kaolin	4	80,000
Lepanto	Gold and copper	137	11,546,849.24
Leyte	Gold and sulphur	17	1,278,190.37
Manila	Coal and caliza marmorea	35	4,600,000
Masbate	Coal	8	1,200,000
Mindoro	Coal	38	5,700,000
Morong	Caliza marmorea	3	60,000
Negros Occidental	Coal	12	1,800,000
Nueva Ecija	Gold	214	12,840,000
Romblon	Caliza marmorea	4	80,000
Samar	Coal	30	4,500,000
Sorsogon	Coal	85	12,750,000
Surigao	Gold and coal	151	14,460,000
Tayabas	Coal	40	6,000,000
Total		2,212	199,868,681.65

TABLE II.—*Summary for Archipelago, by provinces and minerals.*

AMBOS CAMARINES.

Class of claim.	Gold.		Coal.		Copper.		Iron.	
	No.	Area.	No.	Area.	No.	Area.	No.	Area.
First class	241	14,194,456.25						
Second class	55	3,171,614.70						
Third class	286	17,120,000	60	9,000,000	60	9,000,000	16	2,400,000

BATAAN.

Class of claim.	Caliza marmorea.		Granite.		Trachyte.	
	No.	Area.	No.	Area.	No.	Area.
First class						
Second class	1	20,000			2	40,000
Third class			4	80,000		

BENGUET.

Class of claim.	Gold.	
	No.	Area.
First class	4	240,000
Second class	4	240,000
Third class	164	9,840,000

BONTOC.

Class of claim.	Gold.	
	No.	Area.
First class	2	120,000
Second class		
Third class		

TABLE II.—*Summary for Archipelago, by provinces and minerals*—Continued.

BULACAN.

Class of claim.	No.	Area.
First class	9	1,137,571.09
Second class		
Third class		

CAGAYAN DE MISAMIS.

Class of claim.	Gold.	
	No.	Area.
First class		
Second class		
Third class	246	14,760,000

CEBU.

Class of claim.	Coal.		Caliza marmorea.		Petroleum.		Guano.	
	No.	Area.	No.	Area.	No.	Area.	No.	Area.
First class	54	8,100,000	1	20,000	4	600,000	1	20,000
Second class								
Third class	211	31,650,000	1	20,000	4	6[illegible]0,000		

INFANTA.

Class of claim.	Coal.	
	No.	Area.
First class		
Second class		
Third class	4	600,000

LAGUNA.

Class of claim.	Kaolin.	
	No.	Area.
First class	4	80,000
Second class		
Third class		

LEPANTO.

Class of claim.	Gold.		Copper.	
	No.	Area.	No.	Area.
First class	20	1,200,000	2	166,849.24
Second class	2	120,000		
Third class	65	3,900,000	48	6,160,000

TABLE II.—*Summary for Archipelago, by provinces and minerals*—Continued.

LEYTE.

Class of claim.	Gold.		Sulphur.	
	No.	Area.	No.	Area.
First class	6	320,056	3	180,000
Second class				
Third class	5	328,134.37	3	450,000

MANILA.

Class of claim.	Coal.		Caliza marmorea.	
	No.	Area.	No.	Area.
First class			1	20,000
Second class				
Third class	30	4,500,000	4	80,000

MASBATE.

Class of claim.	Coal.	
	No.	Area.
First class	8	1,200,000
Second class		
Third class		

MINDORO.

Class of claim.	Coal.	
	No.	Area.
First class	34	5,100,000
Second class	4	600,000
Third class		

MORONG.

Class of claim.	Caliza marmorea.	
	No.	Area.
First class	2	40,000
Second class		
Third class	1	20,000

NEGROS OCCIDENTAL.

Class of claim.	Coal.	
	No.	Area.
First class		
Second class	12	1,800,000
Third class		

TABLE II.—*Summary for Archipelago, by provinces and minerals*—Continued.

NUEVA ECIJA.

Class of claim.	Gold.	
	No.	Area.
First class	4	240,000
Second class		
Third class	210	12,600,000

ROMBLON.

Class of claim.	Caliza marmorea.	
	No.	Area.
First class		
Second class		
Third class	4	80,000

SAMAR.

Class of claim.	Coal.	
	No.	Area.
First class		
Second class		
Third class	30	4,500,000

SORSOGON.

Class of claim.	Coal.	
	No.	Area.
First class	20	3,000,000
Second class	23	4,950,000
Third class	32	4,800,000

SURIGAO.

Class of claim.	Gold.		Coal.	
	No.	Area.	No.	Area.
First class	61	3,660,000		
Second class				
Third class	30	1,800,000	60	9,000,000

TAYABAS.

Class of claim.	Coal.	
	No.	Area.
First class		
Second class		
Third class	40	6,000,000

TABLE III.—*List of mines*

AMBOS CAMARINES.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims				
1	Esperanza	Gold	2	120,000	The Philippines Mineral Syndicate, Limited.
2	La Concepción	do	2	120,000	do
4	Trinidad	do	2	120,000	do
5	Luisa	do	2	120,000	do
6	Rosalia	do	2	120,000	do
7	Noria	do	1	60,000	do
9	Santa Getrudis	do	1	60,000	do
10	Animas del Purgatorio	do	2	120,000	do
11	San Antonio	do	2	120,000	do
20	Maria	do	2	120,000	do
21	Francisco	do	2	120,000	do
25	San Juan	do	[1]2	81,000	do
93	San Enrique	do	2	120,000	do
63	San Pablo	do	2	120,000	Sociedad Minera "La Bonancita."
69	San Antonio	do	1	60,000	Eugenio Expedido.
32	El Secreto	do	2	120,000	Sociedad Minera "La Bonancita."
33	Mi Porvenir	do	2	120,000	do
34	Santa Marta	do	2	120,000	do
35	La Muy Rica	do	2	120,000	do
	Nueva Galicia	do	2	120,000	The Philippines Mineral Syndicate, Limited.
	Aurora	do	2	120,000	do
	San Ramón	do	2	120,000	do
86	San Rafael	do	2	120,000	Nicolas Carranceja
90	Registro 1st	do	1	60,000	Sociedad García Beltran y Co.
88	Registro 2d	do	1	60,000	do
87	Registro 3d	do	1	60,000	do
89	Registro 4th	do	1	60,000	do
91	Registro 5th	do	1	60,000	do
99	Cusa	do	2	120,000	do
100	Pep	do	2	120,000	do
101	Quim	do	2	120,000	do
104	Santa Barbara	do	2	120,000	Eugenio Expedido
	Felicidad	do	2	120,000	The Philippines Mineral Syndicate, Limited.
102	San Mauricio	do	2	120,000	do
	Doña Guillerma	do	1	60,000	Sociedad Minera "La Bonancita."
98	Doña Maria	do	2	120,000	The Philippines Mineral Syndicate, Limited.
97	Margarita (investigation).	do	[2]2	120,000	do
	Overplus south of San Antonio.	do	([3])	18,200	do
	Overplus north of San Antonio.	do	([3])	45,000	do
	Overplus of San Juan	do	([3])	10,256.25	do
105	Santa Barbara	do	2	120,000	Sociedad Minera "La Bonancita."
106	Don Carlós	do	1	60,000	do
107	Leo Taxil	do	2	120,000	Ramón Cebezudo
108	San Vicente	do	2	120,000	Sociedad Minera "La Bonancita."
109	Padre José	do	2	120,000	do
110	Nueva California 1st	do	4	240,000	Martin Buk & Joaquin Casanovas.
113	Nueva California 2d	do	4	240,000	do
114	Nueva California 3d	do	4	240,000	do
118	Nueva California 4th	do	4	240,000	do
119	Nueva California 5th	do	4	240,000	do
120	Germania	do	4	240,000	do
125	La Candelaria	do	33	1,980,000	Vicente Atienza
121	Magallanes	do	24	1,440,000	Martin Buk & Joaquin Casanovas.
126	San Felix	do	2	120,000	Emilio Sprungli
129	San Ricardo	do	2	120,000	Juan Fernandez y San Luis.
130	El Angel	do	2	120,000	do
131	El Patriarca	do	2	120,000	do
154	San Rafael	do	2	120,000	Aguedo Macondog
151	La Concepción	do	2	120,000	Catalino Flores
150	Santa Balbina	do	2	120,000	do
152	San Nicolás	do	2	120,000	do
148	Caridad	do	1	60,000	The Philippines Mineral Syndicate, Limited.
142	San Ciriaco	do	1	60,000	do
123	Santiago	do	1	60,000	do
143	San Federico	do	2	120,000	do

[1] Incomplete. [2] Investigation. [3] Overplus.

of the Archipelago.

AMBOS CAMARINES.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
1	28	Tumbaga	Mambulao	Apr. 22, 1891	Apr. 24, 1892	July 28, 1892
1	29	Imbong-imbong	do	do	Apr. 25, 1892	Do.
1	31	Dinaanan	Paracale	do	Apr. 28, 1892	Do.
1	32	Calapnit	do	do	Apr. 29, 1892	Do.
1	33	Tingá	do	do	Apr. 30, 1892	Do.
1	58	La Noria	Mambulao	do	Sept. 4, 1892	Jan. 7, 1894
1	61	Calupcup	do	do	Sept. 5, 1892	Do.
1	62	Longos	Paracale	do	Sept. 9, 1892	Do.
1	63	Dinaanan	do	do	Sept. 8, 1892	Do.
2	17	Tumbaga	Mambulao	June 19, 1893	Apr. 19, 1894	July 20, 1894
2	18	Tumbaga	do	do	Apr. 20, 1894	Do.
2	28	Salúbung	Paracale	July 30, 1893	Apr. 30, 1894	Do.
2	42	Gumamela	do	Feb. 28, 1894	May 31, 1894	Aug. 3, 1894
2	20	Ogúis	do	Nov. 11, 1893	May 7, 1894	Do.
2	49	Dinaanan	Mambulao	Oct. 31, 1893	June 6, 1894	Do.
2	5	Togús	Paracale	Sept. 15, 1893	May 1, 1894	Sept. 28, 1894
2	6	Mariconia	do	do	May 2, 1894	Do.
2	7	Mananc	do	do	May 3, 1894	Do.
2	8	Cabongajan	do	do	May 4, 1894	Do.
2	46	Guinobacan-Bata	Mambulao	Aug. 12, 1893	June 2, 1894	Nov. 7, 1895
2	47	Guinobacan-Matandá	do	do	June 3, 1894	Do.
2	48	Gumaos	do	do	June 3, 1894	Do.
2	26	Togús	Paracale	Dec. 30, 1893	May 18, 1894	Dec. 7, 1894
2	37	Rio de Paracale	do	Feb. 6, 1894	May 28, 1894	July 12, 1895
2	38	do	do	do	May 29, 1894	Do.
2	39	do	do	do	May 30, 1894	Do.
2	40	do	do	do	May 31, 1894	Do.
2	41	do	do	do	May 31, 1894	Do.
2	92	do	do	June 8, 1894	May 22, 1895	Aug. 9, 1895
2	93	do	do	do	May 21, 1895	Do.
2	94	do	do	do	May 20, 1895	Do.
2	160	Bejuquillo	Mambulao	Mar. 15, 1895	May 25, 1895	Do.
2	78	Dinaqiutan	do	July 30, 1893	May 16, 1895	Aug. 16, 1895
2	110	Calupcup	do	July 31, 1894	May 15, 1895	Do.
2	4	Tagonton	Paracale	Nov. 3, 1893	May 5, 1894	Aug. 9, 1895
2	115	Pansol	do	June 16, 1894	May 24, 1895	Aug. 16, 1895
2	114	Pansol	do	do	May 19, 1895	Aug. 6, 1895
2	90	Salúlong	do	Aug. 21, 1894	May 23, 1895	Aug. 16, 1895
3	16	Longos	do	May 25, 1895	May 27, 1895	Do.
2	91	Baluarte	do	Aug. 21, 1894	May 23, 1895	Do.
3	32	Manáng	do	May 31, 1895	July 18, 1896	Dec. 31, 1896
3	33	Tagonton	do	do	July 20, 1896	Do.
3	63	Casalogan	do	Sept. 18, 1895	Aug. 10, 1896	Jan. 15, 1897
3	98	Maquina	do	Oct. 11, 1895	July 24, 1896	Dec. 31, 1896
3	99	Lipata	do	do	July 26, 1896	Jan. 15, 1897
3	105	Casalogan	do	Dec. 15, 1895	Aug. 15, 189[illegible]	Jan. 8, 1897
3	108	Cuyuman	do	Jan. 14, 1896	Aug. 14, 1896	Jan. 29, 1897
3	110	Casalogan	do	do	Aug. 17, 1896	Jan. 15, 1897
3	112	Magsimalóc	do	Jan. 29, 1896	Aug. 18, 1896	Do.
3	114	Cabismuan y Coloran	do	Jan. 28, 1896	Aug. 20, 1896	Jan. 29, 1897
3	116	Capalungan	do	Jan. 26, 1896	Aug. 22, 1896	Jan. 8, 1897
3	131	Calangay y Pinaglambian.	do	Mar. 28, 1896	July 27, 1896	Dec. 31, 1896
3	118	Bonotan y Malagangao	do	Feb. 15, 1896	Aug. 26, 1896	Jan. 8, 1897
3	123	Cabugao	do	Apr. 15, 1896	Aug. 7, 1896	Dec. 31, 1896
3	137	Maynanca	do	May 9, 1896	Sept. 2, 1896	Jan. 29, 1897
3	140	Delincuente	do	do	Sept. 3, 1896	Do.
3	143	Monte Maynanca	do	do	Sept. 4, 1896	Do.
4	85	Tigbi	Mambulao	Nov. 25, 1896	May 20, 1897	Jan. 22, 1898
4	49	Ybabang Bulalacao	do	Oct. 26, 1896	May 18, 1897	Mar. 9, 1898
4	47	Bulalacao	do	do	May 17, 1897	Do.
4	51	Gajugaju	do	do	May 18, 1897	Do.
4	33	Dinaquitan	do	Sept. 11, 1896	Apr. 26, 1897	Aug. 31, 1897
4	41	Mambulao	do	Aug. 29, 1896	Apr. 22, 1897	Do.
3	149	Calupcup	do	Mar. 12, 1896	Apr. 19, 1897	Do.
4	39	Mambulao	do	Aug. 29, 1896	Apr. 23, 1897	Do.

TABLE III.—*List of mines*

AMBOS CAMARINES—Continued.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims—Ctd.				
124	San Alfredo	Gold	1	60,000	The Philippines Mineral Syndicate, Limited.
144	San Sebastian	do	2	120,000	do
149	Robinson Grup	do	57	3,420,000	Williams Urquhart
	Second-class claims.				
Overplus between the mines.	Mi Porvenir and Grup. La Candelaria.	Gold	[1] 1	63,125	James Charles Donaldson Sim.
	La Muy Rica, Doña Guillerma, Santa Barbára, Don Cárlos, Padre José, Coto Candelaria, and San Felix.	do	[1] 1	61,736	do
	San Rafael, Quim, and Grup. La Candelaria.	do	[1] 1	10,525	do
	Registro 4th and 5th, Quim La Candelaria.	do	[1] 1	34,900	do
	San Juan, La Candelaria, and San Felix.	do	[1] 1	43,200	do
	La Muy Rica, Don Carlós, San Vicente, and San Felix.	do	[1] 1	16,000	do
	San Juan, Registro 2d, 3d, and 4th and La Candelaria.	do	[1] 1	77,155.50	do
	Padre José and Grup. La Candelaria.	do	[1] 1	75,748.20	do
	Mi Porvenir and Padre José.	do	[1] 1	29,225	do
163	San Carlós	do	1	60,000	William Urquhart
140	El Carmelo	do	23	1,380,000	Vicente Atienza
128	Las Siete Vetas	do	2	120,000	Perfecto Lopez Somoza
145	Santo Tomás	do	2	120,000	Alfredo George White
141	El Bagacay	do	2	120,000	Vicente Atienza
157	Numancia	do	2	120,000	Nicolás Pascual y Cervera
155	Sagunto	do	2	120,000	do
156	Covadonga	do	2	120,000	do
146	La Española	do	2	120,000	Perfecto Lopez Somoza
147	La Australiana	do	2	120,000	do
138	San Jorge	do	2	120,000	Alfredo Georgе White
168	Lezo	do	2	120,000	Pablo Feced
166	La Zarza	do	2	120,000	do
	Third-class claims.				
168	La Constancia	Gold	1	60,000	Juan G. Fernandez & San Luis.
2	Santa Ana	Iron	4	600,000	Mauricio G. Hermann
46	Cerro Paliparan	Gold	60	3,600,000	Edouard C. André
47	Guyaman	do	54	3,200,000	do
48	Togus	do	1	60,000	do
49	Nangca 1st	do	2	120,000	do
50	Nangca 2d	do	2	120,000	do
51	Matalang	do	2	120,000	do
52	Pinagcaramihan	do	1	60,000	do
53	Paracale	do	2	120,000	do
54	Casalogan	do	1	60,000	do
55	Capalugan	do	1	60,000	do
56	Santo Niño	do	20	1,200,000	do
60	Mambulao	do	2	120,000	do
61	Imbong-imbong	do	2	120,000	do
62	Atalaya	do	1	60,000	do
63	Bulalacao	do	1	60,000	do
64	May Cruz	do	60	3,600,000	do
65	Guinobacan	do	2	120,000	do
76	Maculabo	do	48	2,880,000	do
77	Beleguim	Iron	2	300,000	do
78	Edouard	do	2	300,000	do
82	Henry	do	2	300,000	do
83	Ferdinand	do	2	300,000	do
90	Louis	do	2	300,000	do
91	Catharine	do	2	300,000	do
103	La Cobriza	Copper	60	9,000,000	Mauricio G. Hermann
104	Carmelo	Gold	23	1,380,000	do
19	Hanopol	Coal	60	9,000,000	Antonio Fuset

[1] Overplus.

of the Archipelago—Continued.

AMBOS CAMARINES—Continued.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
3	150	Calupcup	Mambulao	Mar. 12, 1896	Apr. 20, 1897	Aug. 31, 1897
4	37	Mambulao	do	Aug. 29, 1896	Apr. 24, 1897	Do.
4	54	Monte Presa	do	Oct. 8, 1896	Apr. 29, 1897	Do.
4	62	Calangag	Paracale	Feb. 10, 1897		
4	65	Manang	do	do		
4	71	Bonco	do	do		
4	70	Maynanca	do	do		
4	68	Cabugao	do	do		
4	66	Cabugao	do	do		
4	69	Tinago	do	do		
4	64	Bontoin	do	do		
4	63	Lipata	do	do		
4	127	Imbon-imbon	Mambulao	May 6, 1897		
4	30	Tagirs, etc.	Paracale	Aug. 21, 1896		
3	126	Monte Presa	do	May 8, 1896		
4	35	Paracale	do	Aug. 29, 1896		
4	43	do	do	Aug. 21, 1896		
4	125	Casalogan	do	Jan. 12, 1896		
4	121	do	do	do		
4	123	do	do	do		
4	87	Da. Maria Timbampalo	do	Aug. 12, 1896		
4	89	do	do	do		
3	145	Dinaanan	do	May 31, 1896		
4	160	Tanday	Nabua	Oct. 19, 1897		
4	158	Cabambanan	do	Sept. 27, 1897		
5	134	Dinaanan	Mambulao	Nov. 8, 1897		
5	17	Bato-Balani	Paracale	Oct. 25, 1898		
5	62	Cerro Paliparan	do	do		
5	64	Cuyuman	do	do		
5	65	Togus	do	Nov. 11, 1898		
5	66	Nangca 1st	do	do		
5	67	Nangca 2d	do	do		
5	68	Matalang	do	do		
5	69	Pinagcaramihan	do	do		
5	69	Paracale	do	do		
5	70	Casalogan	do	do		
5	71	Capalugan	do	do		
5	72	Santo Niño	do	do		
5	76	Mambulao	Mambulao	do		
5	77	Imbong-imbong	do	do		
5	78	Atalaya	do	do		
5	79	Bulalacao	do	do		
5	80	May Cruz	do	do		
5	81	Guinobacan	do	do		
5	92		Paracale	do		
5	93	Isla Calambayungan	Mambulao	do		
5	94	do	do	do		
5	98	Bato-Balani	Paracale	do		
5	99	do	do	do		
5	106	Isla Calambayungan	Mambulao	do		
5	107	do	do	do		
5	119	Malay y Cajaguikjikan	Labo	Jan. 11, 1899		
5	120	Calapuit	Paracale	do		
5	37	Hanopol	Caramuan	Nov. 3, 1898		

Table III.—*List of mines*

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	BATAAN.				
	Second-class claims.				
1	Canteras de Mariveles.	Trachyte		40,000	Aldecoa y Co.
1	Canteras Española	Building stone		20,000	Manuel Menendez Rodriguez.
	Third-class claims.				
42	San Engracio	Granite		20,000	Esteban Riu y Plana
43	Santa Maria	do		20,000	do
44	San Esteban	do		20,000	do
45	San Juan	do		20,000	do
	BENGUET.				
	First-class claims.				
1	Capunga	Gold	2	120,000	Pablo Emilio Hermann
2	Tablo	do	1	60,000	do
3	Acupan	do	1	60,000	do
	Second-class claims.				
7	Arenas de Ytogon	Gold	2	120,000	Pablo Emilio Hermann
	San Pedro	do	2	120,000	do
	Third-class claims.				
57	Antamoc	Gold	60	3,600,000	Edouard C. André
58	Ambuclao	do	60	3,600,000	do
59	Gatipa	do	44	2,640,000	do
	BONTOC.				
	First-class claims.				
1	Encarnación	Gold	2	120,000	Saturnino Villaverde
	BULACAN.				
	First-class claims.				
	De Hizon	Iron	[1]1	111,798.16	Heirs of Hizon
2	Santa Lutgarda	do	1	150,000	Heirs of Anchuelo
3	Constancia	do	2	300,000	Doña Francisca Talag
4	De Concha	do	[1]2	125,772.93	Heirs of Concha
5	San Pio V	do	2	300,000	Pablo Carlós
	Sapang-munti	do	1	150,000	Francisco Sanchez
	CAGAYAN DE MISAMIS.				
	Third-class claims.				
1	Riqueza	Gold	25	1,500,000	Nonito Prim y Llops
5	Dominolog	do	20	1,200,000	Antonio Fuset
12	Cutman	do	61	3,660,000	do
13	Pigtao	do	20	1,200,000	do
98	San Isidoro	do	60	3,600,000	Isidoro Sanger
99	San Luis	do	60	3,600,000	do

[1] Old.

of the Archipelago—Continued.

BATAAN.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
5	149	Punta Gorda	Mariveles	Mar. 7, 1896		
5	144	Lilimbong	do	Mar. 30, 1897		
5	60	Sisiman	Mariveles	Nov. 10, 1898		
5	61	do	do	do		
5	61	do	do	do		
5	62	do	do	do		

BENGUET.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
3	48	Losong	Tublay	July 6, 1895	June 22, 1896	Nov. 28, 1896
3	52	La Trinidad	do	do	June 24, 1896	Do.
3	179	Acupan	Ytogon	Mar. 11, 1896	June 26, 1896	Do.
4	7	Rio Batuang y Nalabagon.	Ytogon	June 30, 1896		
4	5	Piquel	Tublay	July 1, 1896		
5	73	Antamoc	Antamoc	Nov. 11, 1898		
5	74	Ambuclao	Ambuclao	do		
5	75	do	do	do		

BONTOC.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
3	146	Deplas	Sagada	July 28, 1895	June 8, 1896	Nov. 28, 1896

BULACAN.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
		Sapang-bacal	Angat			
7	38	Pinugayan	do	Sept. 9, 1873	Sept. 26, 1876	
7	111	do	do	Feb. 22, 1879	June 23, 1880	Aug. 13, 1880
6	4	Sapang-bacal	San Miguel de Mayumo.	Jan. 22, 1853	June 23, 1856	June 23, 1856
7	129	do	do	Nov. 2, 1882	June 3, 1883	Dec. 7, 1883
1	85	Mantamuro	Angat	Nov. 21, 1892	Apr. 16, 1893	June 9, 1893

CAGAYAN DE MISAMIS.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
5	15	Tacbongbong (Pigtao)	Yponan	May 3, 1898		
5	21	Dominolog	Pigtao	Nov. 3, 1898		
5	30	Cutman	do	do		
5	31	Pigtao	do	do		
5	114	Bitog	Munique & Lagaun.	Nov. 23, 1898		
5	115	Calao	do	do		

TABLE III.—*List of mines*

CEBÚ.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
	Magallanes	Coal	2	300,000	Sociedad Nueva Langreo
	Nueva Langreo	do	2	300,000	do
	Cebuana	do	2	300,000	do
	Portiella	do	2	300,000	do
	La Mestiza	do	1	150,000	do
17	Angeles†	do	12	1,800,000	Ramón Montañez
18	San Julian	do	8	1,200,000	Sociedad Nueva Langreo
46	San Enrique	do	4	600,000	Ramón Montañez
	Rafael Reyes	do	2	300,000	do
56	Carlota	do	1	150,000	Sociedad Nueva Langreo
37	Alfonso XIII	do	4	600,000	Cornelio Roberto Blair Pickford.
57	Maria Cristina	do	4	600,000	do
38	Progreso	do	2	300,000	do
24	Reina Regente	Petroleum	2	300,000	do
	Langob	Guano	[1]1	20,000	Ramón Montañez
	Cantera Santa Rosa*	Building Stone	[1]1	20,000	Fausto Tabotabo
60	Angeles†	Coal	8	1,200,000	Ramón Montañez
58	Alegria	Petroleum	1	150,000	Smith, Bell & Co
	Third-class claims.				
24	Santa Rosa*	Building stone		20,000	Antonio Fuset
34	Danao	Coal	4	600,000	Enrique Spitz
35	Visayas‡	do	4	600,000	do
36	Luguayan‡	do	4	600,000	do
37	Germania	do	23	3,450,000	do
38	Amplicación	do	60	9,000,000	do
39	Cebú	do	27	4,050,000	do
40	Muao	do	44	6,600,000	do
41	Dapdap	do	45	6,750,000	do
96	Patrocinio	Petroleum	4	600,000	Alvaro Beltran de Lis

INFANTA.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	Third-class claims.				
88	Clementina	Coal	4	600,000	Edouard C. André

LA LAGUNA.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
1	Alfa	Kaolin	[1]1	20,000	José Martin y Martinez
2	Beta	do	[1]1	20,000	do
3	Delta	do	[1]1	20,000	do
4	Epsilon	do	[1]1	20,000	do

LEPANTO.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
1	Pilar	Gold	2	120,000	Rafael Yanguas
2	Santa Rita	do	2	120,000	do
3	San Luis	do	2	120,000	do
4	San Antonio	do	2	120,000	do
6	San Alberto	do	2	120,000	José Mills
7	Adela y Micaela	do	2	120,000	do
8	Pilar y Mercedes	do	2	120,000	do
9	Maria Asunción y San Lorenzo.	do	2	120,000	do
10	San Eugenio y Eduarda.	do	2	120,000	do
11	San Fernando y San Isidoro.	do	2	120,000	Federico Lopez Pascual
7	Name unknown, at Santa Barbara.	Copper	[2]2	83,000.62	Venancio Balbas
9	Cántabro Filipino	do	[2]2	83,848.62	do
	Second-class claims.				
7	Carmen	Gold	2	120,000	José Mills

[1] Authorization. [2] Old.

of the Archipelago—Continued.

CEBÚ.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
7	192	Bairan	Danao	June 13, 1887	Jan. 19, 1888	Mar. 13, 1888
7	195	Manganas-auas	do	June 28, 1887	Jan. 25, 1888	Do.
7	197	Silangon	do	July 8, 1887	Jan. 27, 1888	Do.
7	199	Bairan	do	July 14, 1887	Jan. 28, 1888	Do.
7	201	Tugonon	do	do	Jan. 29, 1888	Do.
1	15	do	Compostela	Mar. 17, 1890	Feb. 14, 1891	May 16, 1891
1	16	Sili	Danao	Mar. 26, 1890	Feb. 17, 1891	Do.
2	9	Tag-angilan	Compostela	Sept. 12, 1892	Feb. 11, 1894	July 5, 1894
2	103	Lupá	do	June 30, 1894	Feb. 12, 1895	Oct. 11, 1895
3	57	Camansi	Danao	Mar. 6, 1895	Feb. 27, 1896	June 6, 1896
3	54	Actine	Toledo	Feb. 18, 1892	Mar. 19, 1896	June 19, 1896
3	58	Yidiong	do	July 15, 1895	Mar. 17, 1896	Do.
3	56	Calumampao	do	Feb. 12, 1892	Mar. 14, 1896	Do.
1	49	do	do	June 15, 1891	Mar. 4, 1892	June 18, 1892
1	57	Tanguaya	Catmon	Feb. 15, 1892	Jan. 29, 1893	
1	1	Danahicon	Taburan	Nov. 28, 1888	Feb. 14, 1890	
4	154	Tugonon	Compostela	Apr. 4, 1896	Feb. 5, 1898	Mar. 23, 1898
3	97	Talayon	Alegria	Jan. 7, 1896	Jan. 7, 1898	Mar. 9, 1898
5	42	Panahicon	Taburan	Nov. 3, 1898		
5	52	Camansi	Danao and Compostela.	Nov. 5, 1898		
5	53	Santa Rosa	do	do		
5	54	do	do	do		
5	55	Sili or San Julian	do	do		
5	56	Licos	do	do		
5	57	Santa Rosa	do	do		
5	58	Parel Muao and Cotcot	do	do		
5	59	Dapdap	do	do		
5	112	Sam-ang	Toledo	Nov. 22, 1898		

INFANTA.

5	104	Monte Malolo	Polillo	Nov. 11, 1898		

LA LAGUNA.

3	26	Lupang Puti	Los Baños	Apr. 23, 1895	Dec. 16, 1895	Jan. 10, 1896
3	29	do	do	do	do	Do.
3	31	do	do	do	Dec. 17, 1895	Do.
3	42	do	do	Apr. 3, 1895	do	Do.

LEPANTO.

3	74	Palindan	Mancayan	Jan. 14, 1895	May 23, 1896	Nov. 28, 1896
3	76	Cayaan	do	Mar. 26, 1895	do	Do.
3	78	Dugoan	do	do	May 21, 1896	Do.
3	80	Gatugat	do	June 3, 1895	do	Do.
3	82	Rio Pacan	do	June 13, 1895	May 31, 1896	Do.
3	83	Agadangan	do	June 14, 1895	June 1, 1896	Do.
3	84	Cali	do	June 15, 1895	May 24, 1896	Do.
3	86	Balaan	do	June 24, 1895	May 25, 1896	Do.
3	86	Rio Abra	Cervantes	June 27, 1895	May 18, 1896	Do.
3	95	Gubasan	Mancayan	Dec. 3, 1895	May 29, 1896	Do.
6	7	Magamban	do	Mar. 26, 1856	Aug. 10, 1856	Aug. 10, 1856
6	9	do	do	Jan. 17, 1857		Aug. 12, 1857
4	2	Palindan	Suyuc	May 28, 1896		

TABLE III.—*List of mines*

LEPANTO—Continued.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	Third-class claims.				
66	Dugon	Gold	2	120,000	Edouard C. André
67	Gubasan	do	20	1,200,000	do
68	Cali	do	1	60,000	do
69	Pacal	do	20	1,200,000	do
70	Moderna Isabelita	Copper	2	40,000	do
71	Moderna Montañesa	do	2	40,000	do
72	Moderna Bella Española.	do	2	40,000	do
73	Moderna Belen Echagüe.	do	2	40,000	do
74	Ysmay	Gold	20	1,200,000	do
75	Gatugat	do	2	120,000	do
101	Harmonia	Copper	20	3,000,000	M. C. Hermann
102	La Esperanza	do	20	3,000,000	do

LEYTE.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
	Ntra. Sra. del Carmen.†	Gold	1	60,000	Aldecoa & Co
2	La Amistad*	do	2	120,000	do
3	Bilbaina‡	do	2	120,000	do
	Overplus between the above three.§	do	(1)	20,055	do
4	Santa Rosalia‖	Sulphur	2	120,000	Prudencio Ruiz
5	San Antonio¶	do	1	60,000	do
1	Alfonzo XIII	Petroleum	1	150,000	Smith, Bell & Co.
	Third-class claims.				
6	Cabibijan‖	Sulphur	2	300,000	Antonio Fuset
11	Cajucao¶	do	1	150,000	do
14	Amistad*	Gold	2	120,000	do
15	Ntra. Sra. del Carmen.†	do	1	60,000	do
16	Bilbaina‡	do	2	120,000	do
17	Overplus between the above three.§	do	(1)	28,134.37	do

MANILA.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
2	Cantera Santo Domingo.	Building stone.	(2) 1	20,000	Marcelo Dominguez
	Third-class claims.				
26	Montalban	Building stone		20,000	Ramón Montañez
27	Sablayan	do		20,000	do
28	San Mateo	do		20,000	do
29	Pamitinan	do		20,000	do
30	Binacungan	Coal	30	4,500,000	do

MASBATE.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
1	San José	Coal	4	600,000	José Muñoz
2	Santa Cruz	do	4	600,000	José Muñoz de Bustillo

[1] Overplus. [2] Authorization.

of the Archipelago—Continued.

LEPANTO—Continued.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
5	82		Suyuc	Nov. 11, 1898		
5	83		do	do		
5	84		do	do		
5	85		do	do		
5	86		Agbao	do		
5	87		Bumucun	do		
5	88		Agbao	do		
5	89		do	do		
5	90		Suyuc	do		
5	91		do	do		
5	117	Bumucun	Mancayan	Jan. 11, 1899		
5	118	Mancayan	do	do		

LEYTE.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
7	40	Pinutan	Lilolan	Feb. 6, 1876	June 15, 1877	Nov. 5, 1877
7	70	Tigbanan	do	Nov. 27, 1876	June 16, 1877	Do.
7	68	do	do	Jan. 6, 1877	do	Do.
7	91	do	do	Sept. 28, 1877	May 8, 1878	July 15, 1878
7	90	Monte Caybiran	Caybiran	April 2, 1878	May 4, 1878	July 12, 1878
7	123	Cajucao	Naval	Sept. 4, 1878	May 20, 1882	Dec. 13, 1882
4	150	Su-uy	San Isidro	Dec. 29, 1896	Dec. 25, 1897	Mar. 9, 1898
5	22	Cabibijan	Caybiran	Nov. 3, 1898		
5	29	Cajucao	Naval	do		
5	32	Amistad	Isla de Panaon	do		
5	33	Ntra. Sra. del Carmen	do	do		
5	34	Bilbaina	do	do		
5	35	Pinutan	do	do		

MANILA.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
7	186	Sablayan	Montalban	July 21, 1887	Mar. 17, 1888	Mar. 21, 1888
5	44	Sablayan and Pamitiman.	Montalban	Nov. 8, 1898		
5	45	do	do	do		
5	46	do	do	do		
5	47	do	do	do		
5	48	Binacungan	do	do		

MASBATE.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
7	188	Nabangig	Cataingan	July 16, 1887	Feb. 27, 1888	May 31, 1888
7	189	do	do	July 27, 1887	Feb. 29, 1888	Do.

TABLE III.—*List of mines*

MINDORO.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
	Santa Maria	Coal	2	300,000	Antonio de Yribar
2	Carolina	do	4	600,000	Rafael Cascarosa y Martinez.
3	San Armando	do	4	600,000	do
4	San Rafael	do	4	600,000	do
5	San Claudio	do	4	600,000	do
6	San Joaquin	do	4	600,000	do
7	San Ramón	do	4	600,000	do
8	San Clemente	do	4	600,000	do
9	Prudencia	do	4	600,000	do
	Second-class claims.				
13	San Felix	Coal	4	600,000	Victor Herrera

MORONG.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
	Cantera Santa Matilde.	Building stone	[1] 1	20,000	Angel Tapia y Aragones.
	Cantera Santa Rosa*	do	[1] 1	20,000	Fausto Tabotabo
	Third-class claims.				
25	May Mangá*	Building stone		20,000	Ramón Montañez

NEGROS OCCIDENTAL.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	Second-class claims.				
1	Nuevo Cardiff	Coal	4	600,000	Martin Buk and Joaquin Casanovas.
2	Nuevo Cardiff 2d	do	4	600,000	do
3	Nuevo Cardiff 3d	do	4	600,000	do

NUEVA ECIJA.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
1	La Aurora	Gold	2	120,000	Arturo Carlos Fleming
2	Santa Catalina	do	2	120,000	do
	Third-class claims.				
7	Santiago	Gold	60	3,600,000	Emilio Sprungli
8	Pulo-ni-Anton	do	60	3,600,000	do
9	Tarian	do	60	3,600,000	do
100	Cabu River	do	30	1,800,000	R. Gray

ROMBLÓN.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	Third-class claims.				
20	Romblón	Building stone		20,000	Antonio Fuset
21	Bombon	do		20,000	do
22	Tongo	do		20,000	do
23	San Antonio	do		20,000	do

SAMAR.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	Third-class claims.				
97	San José	Coal	30	4,500,000	Isidoro Sanger

[1] Authorization.

of the Archipelago—Continued.

MINDORO.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
1	75	Painan	Semerara	Mar. 1, 1889	Jan. 29, 1893	May 12, 1893
1	45	Siay	Bulálacao	Jan. 10, 1892	Feb. 1, 1893	Do.
1	44	Napisián	do	do	Feb. 9, 1893	Do.
1	48	Siay	do	do	Feb. 3, 1893	Do.
1	43	Napisián	do	do	Feb. 11, 1893	Do.
1	46	Siay	do	do	Feb. 6, 1893	Do.
1	47	do	do	do	Feb. 8, 1893	Do.
1	42	Napisián	do	do	Feb. 14, 1893	Do.
1	41	do	do	do	Feb. 15, 1893	Do.
4	20	Cataictican	Bulalacao	May 1, 1896		

MORONG.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
7	211	May Puti	Binangonan	Nov. 6, 1886	Oct. 17, 1889	Nov. 18, 1889
7	216	May Mangá	do	Feb. 23, 1889	do	Do.
5	43	May Mangá	Binangonan	Nov. 3, 1898		

NEGROS OCCIDENTAL.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
4	12	Calatoy	Calatrava	Mar. 22, 1896		
4	17	Macasilao	do	do		
4	22	do	do	do		

NUEVA ECIJA.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
2	97	Pulo-ni-Anton	Gapan	May 12, 1894	Mar. 18, 1895	May 1, 1895
2	99	do	do	do	Mar. 23, 1895	Do.
5	23	Pulo-ni-Anton	Gapan	Nov. 3, 1898		
5	24	do	do	do		
5	25	Tarian	do	do		
5	116	Rio Cabu	Mataas añg Pampang.	Dec. 12, 1898		

ROMBLÓN.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
5	38	Romblón	Isla Romblón	Nov. 3, 1898		
5	39	Bombon	do	do		
5	40	Tongo	do	do		
5	41	San Antonio	do	do		

SAMAR.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
5	113		Loquiloco	Nov. 23, 1898		

TABLE III.—*List of mines*

SORSOGÓN.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
4	Palerma	Coal	1	150,000	Villanueva & Co
5	Urgere	do	1	150,000	do
6	Ganalda	do	1	150,000	do
7	San Francisco	do	4	600,000	Emilio Muñoz
8	Perseverancia	do	1	150,000	Villanueva & Co
3	Sodupe	do	2	300,000	Jacinto Gil Gorroño
9	Bilbao	do	4	600,000	do
10	Lucas y Josefa	do	1	150,000	do
11	Chifladura	do	1	150,000	do
12	Presentación	do	2	300,000	do
13	Olaveaga	do	2	300,000	do
	Second-class claims.				
17	Palma	do	2	300,000	Rafael Vich y Roselló
15	Elisa	do	[1]1	150,000	Enrique Gil Gorroño
18	Vizcaya	do	24	3,600,000	Jacinto Gil Gorroño
14	J anito	do	4	600,000	Enrique Gil Gorroño
16	Lidia	do	2	300,000	do
	Third-class claims.				
3	Sin Nombre	Coal	2	300,000	Henry Brodek
4	Paz	do	4	600,000	Enrique Gil Gorroño
10	La Esperanza	do	6	900,000	José Verches y Vera
18	Magallanes	do	4	600,000	Antonio Fuset
31	San Jacinto	do	4	600,000	Jacinto Gil Gorroño
32	San Enrique	do	4	600,000	do
33	San Ramiro	do	4	600,000	do
105	Butuan	do	4	600,000	José María Yesiaz

SURIGAO.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	First-class claims.				
1	La Esperanza	Gold	52	3,120,000	Williams Urquhart
2	Maria y Leopolda	do	2	120,000	Jóse Cortes y Dominguez
3	Mundaca	do	2	120,000	do
4	Andres y Agustina	do	1	60,000	do
5	Vizcaya	do	2	120,000	do
6	Castilla	do	2	120,000	do
	Third-class claims.				
93	Dinagat	Gold	30	1,800,000	Isidoro Sanger
94	Cacub	Coal	60	9,000,000	do

TAYABAS.

No.	Names of mines.	Mineral.	No. of perts.	Area.	Concessionaries, etc.
	Third-class claims.				
79	Good Hope	Coal		600,000	Edouard C. André
80	Cesarine Decourt	do		600,000	do
81	Wealthy	do		600,000	do
84	Franco	do		600,000	do
85	Abondance	do		600,000	do
86	Saint Barbe	do		600,000	do
87	Arbigny	do		600,000	do
89	Jean	do		600,000	do
92	Auguste	do		600,000	do
95	Richfield	do		600,000	do

[1] Overplus.

of the Archipelago—Continued.

SORSOGÓN.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
2	85	Pututan	Bacon	Dec. 21, 1893	May 17, 1895	Aug. 16, 1895
2	86	Vencalon	do	do	do	Do.
2	87	Liguan	do	do	May 19, 1895	Do.
2	88	do	do	Dec. 30, 1893	May 25, 1895	Oct. 11, 1895
2	89	Malabog	do	Jan. 31, 1894	May 15, 1895	Aug. 16, 1895
2	84	Napisay	do	Dec. 20, 1893	Oct. 22, 1895	Dec. 6, 1895
3	3	Calabangan	do	Apr. 28, 1894	Oct. 29, 1895	Do.
3	6	Caticatigahan	do	Oct. 26, 1894	Nov. 1, 1895	Do.
3	11	do	do	do	Nov. 5, 1895	Do.
3	19	Saburi	do	Mar. 24, 1895	Oct. 24, 1895	Do.
3	21	Aguis	do	do	Oct. 26, 1895	Do.
4	168	Burad	do	Nov. 5, 1897		
4	164	Isla de Batan	do	Aug. 10, 1897		
4	170	do	do	Dec. 13, 1897		
4	162	Bahe	do	Aug. 10, 1897		
4	166	Catigahan	do	do		
5	18	Libod	Isla de Batan	Oct. 28, 1898		
5	19	Isla de Batan	Bacon	Sept. 10, 1898		
5	26	Burad y Manila	Isla de Batan	Nov. 3, 1898		
5	36	Carisan	Magallanes	do		
5	49	Isla de Batan	Bacon	Sept. 15, 1898		
5	50	do	do	do		
5	51	do	do	do		
5	121	Birombato y Butuan	do	Jan. 12, 1899		

SURIGAO.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
4	134	Cansuran	Surigao	April 28, 1897	Oct. 15, 1897	Dec. 10, 1897
4	172	Tinabigan	Placer	May 4, 1897	Nov. 11, 1897	Mar. 9, 1897
4	176	Cantuan	do	do	Nov. 13, 1897	Do.
4	180	Isla Campiña	do	do	Nov. 9, 1897	Do.
4	184	Cacatan	do	do	Nov. 18, 1897	Do.
4	188	Tinopan	do	do	Nov. 16, 1897	Do.
5	109	Cagdayano	Dinagat	Nov. 14, 1898		
5	110	Cacub y Dapa	Numancia	do		

TAYABAS.

No. of book.	No. of page.	Place.	Subdivision.	Date of first record.	Date of demarcation.	Date of concession.
5	95	Arroyo Bongaon	Gumaca	Nov. 11, 1898		
5	96	Bambang	do	do		
5	97	Arroyo Caglati	do	do		
5	100	Baao	Mauban	do		
5	101	Sanjirin	do	do		
5	102	Malay	do	do		
5	103	Baao	do	do		
5	105	Mte. Malagonon	do	do		
5	108	Baao	do	do		
5	111	Camagon	Atimonan	do		

Philippine

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BULLETIN No. 3.

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BY

H. D. McCASKEY, B. S.,
Mining Engineer for the Mining Bureau.

MANILA:
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LETTER OF APPROVAL.

OFFICE OF THE MINING BUREAU,
Manila, P. I., August 23, 1902.

The report of H. D. McCaskey, B. S., Mining Engineer for the Mining Bureau, of this date, made to the Chief of the Mining Bureau and entitled "Report on a Geological Reconnoissance of the Iron Region of Angat, Bulacan," is hereby approved and is recommended for publication.

CHARLES H. BURRITT,
Chief of the Mining Bureau.

Approved:
DEAN C. WORCESTER,
Secretary of Interior.

CONTENTS.

MAPS, SKETCHES, AND TABLES.

[For illustrations see back of book.]

PHOTOGRAPHS.

[For illustrations see back of book.]

[NOTE.—The first three plates are the amateur work of the author with an imperfect camera. The others are by Mr. Martin.]

REPORT ON A GEOLOGICAL RECONNOISSANCE OF THE IRON REGION OF ANGAT, BULACAN.

OFFICE OF THE MINING ENGINEER FOR THE MINING BUREAU,
Manila, August 23, 1902.

MR. CHARLES H. BURRITT,
Chief of the Mining Bureau, Manila, P. I.

SIR: In compliance with instructions received from you, and in accordance with the plans of this Bureau, to gather, compile, and distribute information concerning the mineral resources of the Philippines, a field party was organized and placed under my charge during the latter part of February; and the month of March and the first half of April were devoted to an investigation of the iron region of Angat, Bulacan. As the result of the field work, and the subsequent work upon the data, samples, and specimens obtained, in the office, drafting room, and laboratory, I have the honor to submit the following report, together with maps, sketches, photographs, and the tabulated results of analyses.

INTRODUCTION.

It is with grateful appreciation that I here acknowledge the great assistance and constant encouragement given by you through the initial difficulties of this first expedition of its kind under the American régime; and I take great pleasure also in thanking the following gentlemen of the military and civil service for many courtesies that facilitated the work in hand and without which there would inevitably have been annoying and irritating obstaclaes and delays: Maj. Gen. Lloyd Wheaton, U. S. A., then commanding the Department of the North Philippines; Col. Arthur L. Wagner, U. S. A., then adjutant-general of that department; Capt. Ralph Van Deman, Twenty-first Infantry, U. S. A., in charge of the Bureau of Military Information; First Lieut. Julian De Court, Philippine Scouts, commanding the stations of Angat and Norzagaray; Dr. Paul C. Freer, Superintendent of Government Laboratories; Señor Pablo Tecson, governor of Bulacan; Capt. H. T. Allen, Sixth Cavalry, U. S. A., Chief of the Insular Constabulary; Mr. W. W. Warren, senior inspector of Bulacan Constabulary, and others of the Insular Government, of the provincial governments of Bulacan, and of the municipal government of Angat.

The party as organized consisted of the undersigned as engineer and geologist in charge, and of the following: William A. Miller, rodman; Luke E. Sessler, cook; Pantaleon M. Geta, assistant rodman; José Fajardo, chief guide; Sebastian Pelez, guide and axman; Manalo Badasto, guide and axman. In addition to the above we were assisted during the earlier part of the work by William Ackerman, an intelligent and capable young man detailed to accompany the expedition by the Bureau of Military Information; and by escort of seven excellent men under Corporal Faustino Soto, from the provincial Constabulary of Bulacan, who accompanied the party throughout and faithfully guarded the supplies and Government property.

Much credit should be given to William A. Miller, whose active assistance, good judgment, and sturdy common sense in handling the native help were invaluable. The three guides were Tagalos, natives of the town of Angat, where they were employed. They have been called axmen in deference to American usage, and they performed the duties of such in American engineer corps, but they were useless with the ax and were remarkably expert with the bolo; if the term be not too warlike therefor, they were the bolomen of the party. With their long sharp knives they cut the way through what would otherwise be termed the "impenetrable jungle and tropical forest undergrowth." They were gradually taught the duties of flagmen and chainmen, and toward the end of the survey they were doing very satisfactory work.

Their loyalty and their faithful performance of whatever they were given to do were most gratifying. The chief guide really knew less of the trails and of the country than the others, as we found out to our sorrow; but, as there were few trails, and we soon learned those, and as he was more of a leader than the others, and seemed better able to interpret our wants to the other natives whom we employed, or with whom we came in contact, he was satisfactory. As for the native in general, the Tagalos whom I met and knew in Bulacan certainly gave me a most favorable impression, particularly those of the mountains wherein we worked and camped. The farther we went from the railroad and large towns, the more simple and natural the Filipinos were. I found no difficulty in securing all the labor needed. They were willing and glad to work at a peso a day, from the old, gray-haired men down to boys of 12; and they expected this wage no matter what the class of work nor the length of the working day.

Ample field and camp equipment and commissary supplies were obtained, the former through the Insular Purchasing Agent and the latter from the commissary for the Insular Civil Government. This completeness of preparation for the field was a source of satisfaction to the party throughout the trip and is among those things for which acknowledgment has been made to you. The quality of the food supplied by the Insular

Commissary was uniformly good and in packages suitable for transportation and for use in the Tropics.

Transportation of the party and supplies was by rail from Manila to Bocaue; from this latter station we marched across the plain to Angat and into the hills to the site selected for the camp; and the equipment and supplies were transported by carabao carts to Angat over fairly good roads, and by cargadores over the mountain trails to the camp. Owing to the rate of speed obtainable from the carabaos in the great heat of the sun upon the level plain, the progress was slow, even with the animals hitched tandem to a small cart. Coming back from Angat six weeks later, in a heavy rain, the carabaos made excellent time for their class and traveled on through the day without stop.

The party left Manila on the morning of March 3 at 7 o'clock, reached Bocaue at 8, and in half an hour were loaded up and on the road toward Angat. It was decided to camp upon the Ilag-puti, that being the only good water between Santa Maria and Angat, and the teams not going fast enough to reach the latter town that day. Angat was reached at noon the second day. Here the cargadores were secured through the presidente, and the baggage being redistributed, the march was resumed early on the 5th. A site was selected for the camp upon the Bayabas River, just below the little mountain barrio of La Mesa, and affording a central point from which to operate. This was reached by 11 o'clock of the 5th. Good drinking water was not so readily found in these hills as might be supposed, and the camp site was selected very largely because it was just above the fine large Santa Margarita spring of limestone water and just below some wells dug in the sand from which the filtered water of the Bayabas was obtainable.

In this connection I would state that effort was made throughout the work to observe the common laws of hygiene and health, and with some success; for, although everyone in the party, excepting the guides and myself, had some malarial fever during the six weeks, the small medicine chest furnished by the Civil Hospital was required for nothing more serious than for quinine for these fevers and for bandages and liniment for the ordinary sprains and bruises incident to active work in rough country.

The camp selected as the base of operations was utilized throughout the entire work, as it was considered less expensive with cargadores at a peso per man per day than to move the entire force from place to place through the limited area proposed for investigation. The working party, however, consisting of the rodman, the guide and myself, were not thus limited, as we frequently slept out overnight and lived from our haversacks.

Camp was broken on the morning of April 14 and Manila was reached the night of the 16th, the return being made by the route taken in going from here. The guides and the Constabulary accompanied us to Bocaue,

where the former were paid off and discharged and the latter were sent by train to Malolos.

Immediately upon my arrival account was made to you of all moneys received and disbursed during the expedition. It had been my constant effort to keep all expenses within the strict limit of necessity, and this was found a comparatively simple thing to do. The rates for labor and transportation were pretty well fixed and it required merely the usual vigilance to keep within them. As stated before, the rate demanded of American employers for all classes of work was a peso a day. This was high, and one native iron smelter complained to me that while Americans paid this wage he could not keep men at work; on the other hand, I found that with only temporary employment to offer I could not get satisfactory service for less. The total expense account as submitted and approved shows a lower rate per diem than any American survey of similar purpose with which I am acquainted, and this notwithstanding the higher cost of supplies in general here than in the United States.

FIELD WORK.

In order than the scope might be as broad as possible within the time planned for the field work it was decided to divide the work into the following heads:

1. Reconnoissance,
2. Surveying,
3. Geological tours, and
4. Economic investigations.

These overlapped each other more or less, and each of the latter three would seem to have been quite enough of an undertaking for one man during the six weeks; this being particularly true because no satisfactory maps existed upon which geological plotting might be done, because the trails, undergrowth, and forest were so difficult that progress was extremely slow, and because all of the assistants taken into the field were entirely unskilled and it was necessary to give much time and patience to their training. The ordinary physical difficulties arising from work in the roughest of mountain country with poor trails, or none, through mud, water, and the dense jungle, and in the midst of the hot season, have been overcome by thousands of our gallant soldiers and equally hardy prospectors and other pioneers in the Philippines; and, although they have been commented upon by every geologist who has attempted work in these Islands, they are to be taken for granted, and the only excuse for their mention is that to a greater or less degree they unquestionably retard the progress of the work.

Immediately upon establishing Camp Burritt (so named in honor of the Chief of the Bureau), a series of ascents was begun to the tops of the hills and mountains for the purpose of observing and sketching the

country, studying the rock formations in the mass as well as the vegetation and forest growth would permit, and selecting stations for the triangulation work of a survey of the Bayabas River, from the iron region to the confluence with the Angat. Familiarity was thus obtained with the general topography of the country, with the water courses, and with such mountain trails as might be used.

The best map available of this part of Bulacan was found to be one kindly furnished me by Capt. Ralph Van Deman, Twenty-first Infantry, U. S. A., in charge of the Bureau of Military Information, made from compass surveys, I believe, and to a scale of 1:53,360, or 1 inch equal to 1 mile. This map was found to be good as far as the Angat River, but incomplete in the hill country containing the limestone formations and the ore beds. With this as a basis and with data from the Mining Bureau, and my surveys, I have been able to produce a map which, while not itself complete, may be found more satisfactory, I trust, for this interesting eastern portion of Bulacan than what existed before.

The survey work executed was chiefly for the purpose of mapping that part of Bulacan between the Angat River and the iron deposits. For this area I could find nothing of value to suitable scale, and I concluded that time would be well spent in thus covering the ground. The method used was a small tertiary triangulation from peak to peak from the stations of which system points were located for a stadia traverse survey of the Bayabas Valley.

The field notes reduced and plotted enabled me to map the area mentioned. A base line as long as could be measured without the consumption of much time and expense, was laid out in the La Mesa Basin, stakes were carefully lined with the transit at distances apart less than 50 feet, and measurements were made with a steel tape from centered tacks driven in the stakes. Levels were then run on the stakes, and the distances, and finally the entire base line was reduced by computation to the true horizontal. The measurements and levels were all repeated before reduction and the means were taken for that purpose. The differences were extremely small. Every effort was made to approximate accuracy because the extremely hilly and difficult nature of the country necessitated so short a line that the greatest possible nicety was required. The device of repeating all angles of the system was also used for the same purpose. Some unavoidable delay and annoyance were caused by the use of native flagmen, particularly when they were at distant stations and could not be intelligently communicated with; but they were ever willing, and they carried out as well as they could what they understood to be their instructions. Their mistakes were natural after all; after having left their stations once or twice before all of the required angles had been read they showed their good spirit, if not their good judgment, by afterwards remaining standing rigid in the hot sun for an hour or more rather than make the mistake again. Several methods of signaling

were devised for communicating with them, but these were only partially successful.

The stadia traverse surveys were as carefully executed, all ordinary precautions for accuracy being taken at all times.

It would be a matter of greatest satisfaction to me to be able to present with this brief report a complete map with contour topography on a scale of 400 feet equal to 1 inch; but with the time and assistance at my disposal and with the pressure of other duties in the field such an undertaking was clearly impossible. The general plan followed throughout the expedition was to accomplish as much as could be done along the various lines decided upon and within the given time and scope. A more detailed topographic survey at this time would have consumed much time, and therefore expense, as the narrow valleys and steep hills were in almost the entire area thickly covered with dense tropic undergrowth or heavily wooded. Lines of sight would have necessitated continued cutting, and every foot of progress would have been slow and laborious. But little land has been cleared and the forest is for the most part virgin. It would seem judicious therefore to anticipate detailed work of the highest accuracy by exploratory surveys until better maps are had upon which to outline more expensive work.

Unless the field geologist be supplied with abundant time and facilities for first making a topographic map and from that a geological map he should go to his labors with the results of topographic work in his hands. It did not seem possible or wise to me for the reasons given in the perceding paragraph, to attempt the location of all geological horizons and the plotting of the various geological areas. This work will follow, I trust, in due course of time when sufficient trustworthy data will have been gathered to make such a map reliable. The materials are not yet at hand for this culminating stage of field geology and an attempt to attain at this time the object desired would result in an imperfect map, which might be suggestive, but which would probably be misleading at best. Mr. Richard von Drasche has with commendable energy and purpose begun such a map of a portion of Luzon; but that his data was not sufficiently complete to warrant the plotting of such extensive areas as he attempted has been shown by the later work of Señor Abella, possibly the most distinguished geologist of all the former inspectors of mines. That *one,* at least, of Mr. von Drasche's conclusions upon incomplete data *was* correct, however, I shall attempt to show in a later portion of this report.

My geological tours were along the ravines and water-courses, across the ridges and hilltops, and over part of the rolling country between the hills and the Angat River. I visited springs and caves and brought back to the office a suite of about a hundred and fifty specimens, some of which have been analyzed and not all of which have I had time as yet to thoroughly work over. For lack of time and of complete facilities for this

class of work, the rocks to be analyzed, as of more immediate economic importance than the others, were referred to the Bureau of Government Laboratories, and to the chemists of that branch of the service I am indebted for the analyses herein given.

A diligent search was made for fossils during the progress of the field work, but with the exception of three or four very imperfect ones from the Baras-bacal limestones none were found.

The economic investigations were confined to a careful study of the native method of iron smelting and of lime burning in addition to the securing of such information as I could obtain concerning the mineral resources of this part of Bulacan. I must express my indebtedness to Señor Mariano Suarez, treasurer of the town of Angat, who operated the only furnace in blast in this region during the time of my visit, whose plant I inspected several times, and to whom I owe acknowledgment for many details always courteously given. Further interesting information was obtained from Doña Maria Alteza Fernando, whose new camarin was being built during the time of my visit and whose *maestro,* or smelter boss, told me much from his long experience in his special work. I gladly acknowledge the uniform courtesy and attention shown by all these smelter people engaged in this most interesting and useful industry.

PHYSICAL AND GEOGRAPHICAL.

The Province of Bulacan lies within the central part of Luzon, its boundaries touching those of Nueva Ecija on the north and northeast, Infanta on the east, Rizal on the south, Manila Bay on the south and southwest, and Pampanga on the west. The eastern boundary is part of the crest of the great cordillera of Luzon, and part of the western boundary is the extensive Candaba swamp, which marks a pronounced depression in the low plain between the cordillera and the Zambales range. In general, therefore, this province lies tilted toward the east and the rainfall caught in the mountains and foothills makes its way west. That part of the main range constituting the extreme eastern boundary, the long spur running from the northeastern corner of the province almost to San Miguel de Mayumo, and the series of hills and foothills parallel to the range and extending west as far as Angat and San José del Monte, constitute the hilly portion of Bulacan, and this in area is a little over half the province. This is the undeveloped part, and it contains but a small portion of the population; and herein lie the mineral deposits and springs, the valuable forests, and the beautiful little mountain valleys and basins that must sooner or later prove very attractive to American farmers here.

The Rio Grande de Pampanga flows across the southwestern corner of the province, emptying into Manila Bay by many mouths. The Angat is the most important river in Bulacan, and with its many tributaries it drains the greater portion of the province. Rising in the extreme north-

east between the Pahalang Mountains and the main range, it flows south, receiving the waters of the Malabid and the Ipo from the east, then turns west flowing past Norzagaray and northwest receiving the Bayabas just below Angat; from here it flows west past Maronco and San Rafael, turns south between Bustos and Baliuag to Quinga, from which place it flows west, emptying into the Rio Grande de Pampanga near Calumpit.

The Meycauayan, Marilao, Ilag-puto, Bocaue, Guiquinto, and Divisoria are short streams flowing south and southwest and emptying into the bay by many mouths south of the Angat, and the Maasin (Upig), Garlang, Balaong, San Miguel, and Buto form a series of mountain streams rising in the foothills north of the Angat and flowing west emptying eventually into the Rio Grande de Pampanga.

Almost the entire area between the roadway of the Manila and Dagupan Railroad and the bay is low, swampy land intersected by the numerous esteros of the delta of the Rio Grande. These form, from their very number, the most convenient means of getting from place to place in this part of the province.

There are many mountain limestone springs of cool, refreshing water, such as the Santa Margarita spring, on the south bank of the Bayabas, just below La Mesa where the river cuts through the limestone formation, and where through the joints and fissures the waters gush out from the rock cool and sweet and clear. In addition to these, however, there are two well-known groups of mineral springs, both of which are called Sibul, which is the Tagalo word for spring. Notes upon the history, chemical and medicinal properties of these springs are given here without apology; they are abstracted partly from records in the Mining Bureau, partly from my own notes and given largely for the benefit of invalids and physicians who may not find the information otherwise available; and in a later part of this report, notice will be taken of such geological information as exists upon the subject.

NOTES ON MINERAL SPRINGS.

In the early part of 1891 the principales of San Miguel de Mayumo petitioned the Governor-General to allow them to construct a reservoir for the utilization of the surplus waters of the mineral medicinal springs at Sibul. This was granted May 13 of that year, upon the condition that the people of that vicinity should be given gratuitous use of the waters of the reservoir.

The inspector of mines was instructed on June 16 to locate a site for this reservoir so that the rights of the Government in all springs of this class should not be prejudiced.

Señor Abella, the inspector of mines at that time, went to Sibul and found that the natives had anticipated his arrival by enlarging the openings of two adjoining mineral springs to such an extent that they would have received very much more than the surplus waters for the reservoir.

Their excavations had also seriously impaired the respective virtues of the two springs, "San José" and "San Miguel," by mixing the waters; and all this in direct violation of the regulations of the Royal Decree of February 27, 1890, which stipulate that "the establishments of mineral waters of Cuba, Puerto Rico, and the Philippines, designated for the cure of whatever infirmity, shall be under the jurisdiction of the Ultramarine Minister, to be directed in conformity with these Regulations." (Chap. I, Art. 1.) Also that "no new establishments of medical mineral waters may be dedicated to the public service for therapeutical purposes until the Ultramarine Minister has first declared the public utility of the waters and conceded the corresponding authorization for its opening." (Chap. II, Art. 5), and also that "if he (the Governor) should decide favorably upon the construction of the establishment he shall order to be made the plan prescribed by paragraph 2, article 8; and, with the advice of the mining engineer, and a medical director by fixed appointment (if there be such) he shall indicate the perimeter of expropriation to be extended, of the territory adjacent to the spring, for the erection of the establishment and all of its dependencies." (Chap. II, Art. 13, Par. I.)

Upon noticing these infractions of the law and the endangering of the usefulness of the spring, Señor Abella at once reported the facts to the governor of Bulacan and to the Governor-General of the Islands, making suggestions to the latter which were approved and ordered carried out. These suggestions embraced the establishment of two circular zones with the baths as a center, within the first of which no excavation or construction of any kind might be permitted, and within the second of which there be allowed no excavation to a greater depth than 2 meters. These suggestions seem worthy, being based upon a geological study of the formations there found; and they were intended to work for the conservation of the greater public benefit from the baths.

Not until November of 1891 could the inspector proceed with the demarcation of the zones, owing to the heavy rains. He then performed the work and submitted a report with plans, copies of which are herewith given, showing the location of these interesting and valuable medicinal springs.

Abella, in his report, assumes that these springs are caused by the uplifting, folding, and breaking of the strata by the extrusion from below, of modern augite andesites. From the fact that the overlying strata are alternate layers of sandstones and shales, more or less porous, based upon limestones, because of the low thermality of the waters, and because of their fluctuations in volume according to the season, he also infers, and probably correctly, that waters of infiltration meet the subterranean waters released by the fracturing above mentioned, and that the final flow from the mouths of the springs is that of mixed subterranean and surface water.

The second visit of the inspector to these springs, which led to a more detailed study of them and to a chemical analysis and to the gathering of physical data, was brought about in rather a curious way.

In 1893 the medical director at the baths wrote to the "Department of Beneficence and Sanity" requesting to be relieved of his responsibilities and stated the following reasons: "The increasing difficulties he encounters in the execution of his duties, not only because of the continuing reasons and protests of the public who resist the payment of dues, but more especially for the nonexistence of an establishment, and lack of installation of apparatus for the technical employment of the waters; neither is there an office for the medical director nor anything else to harmonize with the official decorum and the delicate mission," etc. He further states "that as an extraordinary credit has been conceded for the purpose of commencing the work on such an establishment" he would be glad to give his services, upon the same salary as he then drew, to the commission then at work upon the mineral springs of the Archipelago.

The indorsement upon this petition, written by the Chief of "Beneficence and Sanity," probably gave the medical director food for thought and reminded him that even admitting that the bathing establishment was not then in the condition in which it should be by law for the use of the public, notwithstanding the explicit instruction of the Royal Decree above quoted, and admitting that the director was not provided with a suitable office and might thereby have been subjected to more or less official indignity, still there was work to do.

He was informed that the ground should be cleared and prepared for the new buildings projected, and that particularly all vegetable decaying matter and other matter subject to putrefaction should be removed as it had been repeatedly reported in Manila that invalids at the springs had frequently contracted fever during their stay at Sibul; he was also informed that, as a number of physicians had complained that the waters of the baths no longer gave the marvelous curative results for which they had become famous, a minute physico-chemical study should be prosecuted to determine the causes of such changes, if any, and he was further advised "to collect topographical, medical, geological, and meteorological data and notes respecting the flora and fauna of the locality," all of which were to be embodied in a report which should be the basis for further proceedings.

The recommendations sent with this indorsement were two, and the second is of interest because it brought about two more very careful studies of the waters, the result of which are here included. These recommendations as confirmed by the Director-General of Civil Administration, and as carried out, were: "First, that the resolutions relative to the medical director of the Sibul baths be suspended until it can be determined to a certainty if these springs have suffered a qualitative alteration

that may have modified their therapeutical action; in which case, it would be necessary to suspend the execution of the works. Second, to send this expediente to the General Inspector of Mines in order that as quickly as possible the waters may again be analyzed. * * *"

In November of 1893 the inspector of mines, Señor Enrique Abella, went to Sibul, with apparatus and assistants, and he verified his former geological reconnoissance and obtained data for a complete report upon the waters of the springs. He found few and slight changes in the waters indicated by the differences between his results and those of the Centeno Commission of 1885; and these variations he ascribed, not to the springs themselves, but, partly to the different details of methods used in the analyses, and partly to the varying proportions of surface to subterranean waters, according to the seasons of the year. The waters had not deteriorated.

The results obtained by the second commission were published in the official Gazette of January 28, 1894, but, as Abella says, "They were mistakenly interpreted by the Inspection of Beneficence and Sanity * * * and therefore has made it necessary, as the Governor-General considered, to make a new study of the spring."

So, all of this expensive and laborious work was repeated in February, 1896, and as Abella and his colleague had executed the analyses before, and each had checked the work of the other, Abella, who was still president of the commission, detailed the new member, Don Antonio Luna y Noveccio, professor of the Municipal Laboratory, to take exclusive charge of the chemical analyses of the waters. The results thus obtained agree almost exactly with those of Abella in 1893, and very closely with those of Rosario in 1885. The mean of the three analyses is here given as representing the average conditions of flow and of mineral constitutents.

These analyses were all performed upon the waters of the San Rafael spring of Sibul. The San Matilde waters show similar results, and from the position of this spring with relation to the folding and fracturing of the strata, it is considered merely another outlet of the same body of underground waters as furnishes the waters of the San Rafael. The San José spring, which is ferruginous, and which flows only in the wet season, is not considered with the two springs above mentioned, because it is undoubtedly merely supplied by surface waters filtered through the strata and taking up minute quantities of iron in their descent.

The final report upon the San Rafael spring shows:

First, that the temperature of the waters (28° C.=82.4° F.) has remained constant throughout the twenty-four hours of the day and during all the seasons of the eleven years up to 1896.

Second, that although the spring is of subterranean origin its flow is augmented by quantities of surface waters varying according to the season. Thus, in April, when the season is dry and the conditions normal,

the flow is 57 liters per second; in February, when the effect of the rains is still felt in the mountains, the flow is 77 liters per second; and in November, when the storms prevail, the flow increases to 85 liters per second.

Third, that the quantity of sulphuretted hydrogen varies from year to year, apparently in cycles, as is common in other springs where the sulphydric acid is a notable constituent, but that this variation does not affect the value of the spring.

THE SIBUL OF SAN MIGUEL.

There were three springs in 1885, at the barrio of Tartaro, or Sibul, about 10 kilometers from San Miguel de Mayumo of which one, the San José, was ferruginous, was supplied by surface waters, and therefore inconstant in flow, and has since lost its identity by having been merged with the waters of the San Rafael. The second spring, the San Matilde, is but another outlet of the waters which furnish the flow from the San Rafael.

Connected with this latter valuable and well-known spring, the Spanish Government had established baths and placed them in charge of a medical director. Patients were sent to the San Rafael baths from Manila, and the waters were famous for their curative properties.

SAN RAFAEL SPRING.

In a small ravine, to the northeast of the church of Sibul, is found the San Rafael spring, the waters of which collect in a small pool about 5½ meters in diameter. In the bottom of the pool there is a deposit of calcareous tufa as a product of sedimentation. The water gushes out profusely from a small crevice in the rock upon which this deposit occurs. There is an orifice in the east wall of the pool, a few centimeters above the surface of the San Rafael waters, which furnishes an outlet for the San José spring, and the waters of the two springs are thus mixed and flow from the San Rafael together.

The temperature has always shown the same reading and is 28° C.= 82.4° F. The water is clear and transparent in small quantities, and is of a light bluish tint when observed in large volumes. The odor is strongly that of sulphuretted hydrogen, and the taste is that characteristic of the same gas. Litmus paper is unacted upon by the water, but paper soaked in freshly prepared lead acetate is blackened both by immersion and by suspension.

The water is spontaneously gaseous and bubbles of liberated gas rise to the surface, both when the water issues from the spring and when it is contained in a bottle or in a glass.

The average flow is 73 liters per second, the constant temperature 28° C., and the mean density 0.998443.

The therapeutic uses of the San Rafael waters are recommended for *dermatosis húmedas,* ulcers, herpes, chronic gastro-intestinal catarrhs, dyspepsia, chronic dysentery, hepatic tumors, and menstrual disorders. The waters should not be used by those having affections of the heart, or the gout.

The waters should be used in the bath, and doses of from two to four glasses daily may be taken internally.

The San Rafael season is from November to May, when the waters are normal and when the climatic conditions are most salubrious and conducive to the rapid convalescence of the invalids.

SAN MATILDE SPRING.

About a kilometer to the north of the preceding, and flowing into a pool excavated in the plain, the San Matilde spring is found. Upon leaving their basins the waters of both the San Rafael and the San Matilde springs flow into the Rio Chico. There is an abundant escape of gases as shown by the bubbles rising to the surface.

The water is clear and transparent in small quantities and is slightly opaline and of a bluish tint when viewed in the mass. It is sulphydric in odor and taste, of an acid reaction so slight as to be almost imperceptible, and is of minute variation in temperature.

When used in the bath it produces a general excitation more or less intense and increases the activity of the reflex power of the nervous system. Taken internally it occasions a stimulation in the gastro-intestinal apparatus, related in intensity with the state of irritability of the organs. In small doses it augments the contractive force of the muscular tunic of the stomach, stimulating the circulation and materially modifying the digestive functions, facilitating the complete absorption of substances that can be assimilated.

The oxidation and temperature are therefore augmented, the circulation is more active, and the breathing more ample.

In doses of 200 grammes, repeated several times during the day, the excitation of the stomach is more intense, and a great part of the water passes to the intestines, where it produces an exosmotic current, awakens the contraction of the muscular tunic, and originates evacuations of a dark color in which dominate the coloring elements of the bile, the mucus, and the cellular detritus.

If the doses exceed 500 grammes, as they do in the case of almost every invalid at Sibul to whom they are administered, the dialytic action is mechanical, and the evacuations are preceded by a sensation of very oppressive burden and great pain.

These waters of the San Matilde spring are recommended for cases of *dermatosis húmedas,* chronic catarrh of the digestive tube, dyspepsia not related with alterations of the texture of the organ nor with a general

morbid state, tumors of the liver and of the spleen, neuralgia provoked by hysteria, leucorrhœa, menstrual hemorrhage, and chronic parenchymous inflations of the matrix sustained by the herpetic constitution, or by anœmia.

The waters are useful in cases of chronic dysentery when the disease has not progressed too far and the alterations of the mucous intestinal texture are not considerable; and they are particularly useful, like those of the San Rafael spring, in dysentery originated by circulatory overthrow of the vena portæ and when this infirmity is shown in persons subjected to the influence of herpes.

The waters should be used in baths of short duration and in carefully graduated internal doses not exceeding 400 grammes; and the season for treatment is from November to March.

THE SAN JOSÉ SPRING.

This spring, as before stated, is of small volume and its waters flow into those of the San Rafael. The supply being from the surface, the flow is more or less uncertain.

The water is colorless, with a slight sediment, without odor, and of slight perceptible taste of ink. It is without the evolution of spontaneous gases and is of neutral reaction.

The use of these waters is recommended for chlorosis, anæmia, dyspepsia, gastralgia, and for other disorders of the digestive tube, for leucorrhœa, and for all states of convalescence characterized by general debility.

The waters are not advised for gastro-intestinal disorders with organic lesion.

The dose recommended is from one to three small cups a day, and the season is from November to May.

THE SIBUL OF NORZAGARAY.

Upon crossing the Angat or Quingua River at Norzagaray, passing through the barrio of Matictic and traversing a fairly good road, over foothills and valleys for about 2½ miles to the northeast, one arrives at the banks of the Mabato arroyo. Here the road ends abruptly, and its continuation is a narrow footpath, that follows up the stream bed for a short distance and then makes northeast over the hills to the little mountain village of Balite. The Mabato rises to the southeast of the Bocol limestone hills, flows past the southern hill of this range and turning southwest empties into the Angat River at Norzagaray.

On the south side of the creek about 300 feet below the road there is a little cup-shaped basin 3 feet in diameter and 3 feet deep, at the base of the hill, in which I found in April some mineral water almost stagnant from the small volume of supply, bluish in color when clear, with a heavy

black muddy sediment, and with strong odor of sulphuretted hydrogen. This was called by the Spanish the Dilain spring. About 350 feet above this spring, just beyond the terminus of the road and on the north side of the Mabato, a small stream of clear water comes through a fissure in the limestone of which the Bocol hills are constituted, discharges into a basin cut in the rock, the outlet of which is a channel a few feet long. Through this channel the waters discharge into the Mabato only a foot or two below the level of the spring. This is the spring called by the commission on mineral springs, of 1885, the San Mariano spring, in an attempt to avoid the confusion from the use of the Tagalo word *Sibul,* which means *spring* and which the natives use for both these waters, near Norzagaray, and for those near San Miguel de Mayumo.

When I visited this place in April, 1902, I found no buildings of any kind, although I was told that an American prospector had located and staked out this spring, constructed a small nipa house in the vicinity and was living there. I found the remnants of a bathing tank of rough masonry at the Dilain spring, and parts of a tile pipe line, and some slight masonry arching to strengthen the opening, at the San Mariano. The natives said that ten years before my visit, or in 1892, the sitio of Sibul consisted of 18 or 20 houses. The people of Angat, who sent to these springs for the waters, were willing to pay a medio peso for a quart bottle, as great faith has been entertained for years in the curative powers of the waters. I was also informed that the Spanish Government some years ago had planned rather an extensive sanitarium here, but that for some reason or another it had not been constructed.

My brief observations would suggest that this or any other available part of the hill country of Bulacan would be suitable for more rapid convalescence than might be possible in Manila or in the lowlying plains and fields adjacent to the bay.

During the midst of the hot season I found the air refreshing and comparatively cool in the shade, the water of the mountain streams clear and sweet and uncontaminated, apparently salubrious and healthful. At night we were quite comfortable under blankets; every morning cool, bracing mountain breezes blew; and out of the direct rays of the sun the air was refreshing even through the middle of the day. We were not annoyed at any time during our six weeks in the hill country by mosquitos. It would seem that should the waters of either the Sibul of Norzagaray or those of San Miguel be considered as valuable by the American physicians and government as they were held by our Spanish predecessors, sanitariums might be established at or near these places with great profit to the convalescents. The baths of Bulacan are quite readily accessible the one near Norzagaray being particularly so. A fair carriage road exists between the railroad station of Bocaue and the town of Norzagaray, and the remains of a road that should be readily repaired lead to the Sibul. The river can be forded during the dry season, and

the entire distance, from Manila to the Sibul, can be made in from five to six hours.

During my visit in April, the hottest part of the year, the Mabato creek was running and the San Mariano spring flowing. The Dilain spring, on the other hand, was almost without flow, the outlet from the basin just trickling over the sands to the creek.

THE DILAIN SPRING.

The waters of the Dilain spring are clear, transparent and colorless in small quantities and bluish when viewed in the mass. There is a heavy, black sediment, partly in suspension, which, with the strong odor of sulphuretted hydrogen, and the bitter, salty, sulphydric taste, render the spring most unattractive.

The water is slightly acid and effervescent. It is useful, both in the bath and internally, for herpetic affections, scrofula, in all its manifestations, infirmities of the urinary passages, articular tumors, and catarrhal affections of the matrix.

THE SAN MARIANO SPRING.

This spring flows through a crevice in the semicrystalline limestone rock on the north side of the Mabato, within 6 feet of the edge of the water in the dry season, and the waters collect in a small basin in the rock not more than a foot above the level of the creek. It will readily be seen, therefore, that when the annual rains begin, and the waters of the mountain stream rise, the spring will flow into the creek below surface level, and its identity will be lost. Through two other small fissures of the limestone strata, at the contact with the water, very small streams flow into the Mabato. In each of the cases the water coming through the rock, upon mixing with the waters of the creek, leaves a fine white precipitate. This calcareous precipitate is also found in less degree in the small basin from which the waters of San Mariano find their outlet.

A careful test with a standard thermometer of the temperature of the San Mariano spring, gave me, on April 1, 1902, a reading of 77° F., which corresponds to 25° C. The Spanish commission in February of 1885 found a temperature of 26.5° C. with the atmosphere at 26° C.

The San Mariano waters are clear, transparent, and colorless in small quantities, and bluish in the mass. The odor and taste are those of sulphuretted hydrogen, the reaction is neutral, and the water is noneffervescent.

The waters are recommended in the bath and to be taken internally, for cases of chronic gastro-intestinal catarrh, dyspepsia, tumors of the liver, in menstrual disorders, in herpetic manifestations, and in *dermatosis*.

The season for the use of the San Mariano and the Dilain springs is from November to May.

FLORA AND FAUNA.

A careful study of the flora and fauna of these Islands is of great importance in the solution of our geological problems here; and it is hoped that eventually there will be some department of the Insular Government corresponding to the Smithsonian Institute at Washington. No exhaustive research has as yet been made by me to ascertain to what extent work has been done in these fields in Bulacan. During our short tour, however, I interested William A. Miller in getting what information he could concerning the most important forest trees found in the hills in the neighborhood of the iron deposits. We found the natives rather intelligent upon these subjects, and surprisingly interested in our many questions about them. These wild people are nature's children, and many of them know their woods and streams fairly well.

Much credit is due Mr. Miller. It is my opinion that if he were to dedicate himself to the work of a collector he would find employment for which he is particularly fitted. We could give but odd moments, during our tramps, to the gathering of information of this kind, and we did nothing in botany proper.

The hills of Bulacan are rich in varieties and numbers of birds, some of which are songsters. We recognized the Calao bird of the Tagalos (*Buceros hydrocorax*), a large hornbill with bright plumage and a remarkably red bill and head several inches long, a fruit eater and highly prized by the natives for its flesh; the jungle bird (*Gallus gallus*); and the Paloma de puñalada of the Spaniards (*Columba cruentata*), a beautiful dove with a white breast, in the midst of which is a blood-red spot as if from a dagger thrust. There are many birds that fill the air with their songs and cries, and among them kingfishers of gorgeous colors, some birds, that I thought to be orioles, and, along the water courses, herons, snipe, and plover.

Among the animals was the Philippine monkey (*Macacas philippinensis*) called *maching* by the natives; wild boar and deer, and wildcats; and there is a very interesting fruit bat of great size, one that I killed measuring 49 inches between tips of extended wings. A large colony of these fruit bats lived in the trees on the west side of the Baras-bacal Hills, hanging in such numbers that the trees seemed completely draped in mourning. These bats mounted in the air at sunset and flew over our camp to their feeding grounds. They seemed arranged in one long column to the number of 6,000 to 10,000 by our estimates. The natives frequently asked us to kill them, as the flesh is highly prized. These bats have the head of a fox and are of great size, even the young ones just able to fly being larger than our house bats.

An interesting group of insects is found in the woods and fields among which are the large red ants whose bite is very painful, and who make themselves nests of the size and shape of a football by bending

together the living leaves of the tree and cementing them at the edges; and a spider that I found in the inner recesses of the Puning Cave, whose legs numbered seven; those nearest the head measuring 5½ inches.

Among the trees observed by Mr. Miller in the fields and hills of eastern Bulacan, of which brief notes were made, with sketches of the leaf and flower, are the following:

Tagalog name.	Scientific name.	Group.	Where observed.
Acle	Pithecolobium acle	1	Near Bayabas barrio.
Alibambang	Bauhinia malabarica		Foothills and mountains.
Anilao	Columbia anilao	4	Sampaloc barrio.
Aninapla	Albizzia procera	3	Bayabas River.
Antipolo	Artocarpus incisa		Bocol Mountains.
Balete	Ficus		Bayabas River.
Bayabas	Psidium guyava	3	Mabato Creek.
Bayoc	Pterospermum blumeanum	3	Sampaloc barrio.
Binayuyo	Antidesma cumingii	4	Bocol Mountains.
Calumpang	Sterculia foetida	4	Do.
Catmon 2d	Dillenia philippinensis	2	Bayabas River.
Cupang	Parkia roxburghii	3	Mount Calabaza.
Himbalao 2d	Excoecaria	4	Mount Sampoloc.
Lanete	Wrightia ovata	1	Mabato Creek.
Lauan	Anisoptera thurifera	3	Foothills and mountains.
Lujong	Diospyros		La Mesa barrio.
Mayapis	Dipterocarpus turbinatus	3	Bayabas River.
Narra	Pterocarpus indicus	Superior	Foothills and mountains.
Panao-balao	Dipterocarpus vernicifluus	3	Mount Calabaza.
Pandacaqui	Tabernaemontana	4	Mabato Creek.
Pandan	Pandanus?		Bayabas River.
Sampaloc	Tamarindus indica	3	Do.
Tanguile	Dipterocarpus polyspermus	2	Mountains.
Tampoy	Eugenia jambos		Pangisijan Creek.

Our notebook containing sketches and field notes concerning the above trees was referred to the Forestry Bureau for such use as might be made of it. I am indebted to that Bureau for supplying the scientific names given above.

In general the hills and mountains of eastern Bulacan are heavily wooded. Clearings have been made in the immediate vicinity of the little barrios and in the foothills, but the higher mountains are rich with closely crowded standing timber, as may be observed in photographs accompanying this report.

GENERAL.

Bulacan is a small province but a very rich one; and the well-irrigated lowlying lands yield annually large quantities of rice; sugar cane, corn, and indigo are also cultivated. The fine, ripe yellow corn was being brought into Angat during the first weeks of March, and much of it that I saw was apparently of excellent grade. The soil is rich and fertile and would seem a most profitable field for experiments with modern farming methods. Much of the best of the lowlands at present is owned by the Friars, but with the success of the negotiations now being made for their release it is to be hoped that many broad acres will soon be freed for a really valuable test of what *can* be done with the productive lands of the Philippines.

Bulacan is under a most successful civil government, ably conducted by Señor Pablo Tecson and his associates. Governor Tecson was the best

leader in the province during the insurrection, and he won the highest reputation for honor and military ability. He eventually became convinced of the futility, and the mistake, of resistance, and he surrendered a large and well-equipped and disciplined body of troops. He is greatly loved by his people, and I was told by several of them that his attitude has had much to do with the present peaceful and gratifying condition in Bulacan.

The capital of the province is at Malolos, and the largest towns with their approximate populations are as follows:

Angat	8,000	Malolos	15,000
Baliaug	14,000	Norzagaray	5,000
Bocaue	10,000	Paombong	10,000
Bulacan	13,000	Pulilan	10,000
Calumpit	15,000	San Miguel de Mayumo	20,000
Hagonoy	20,000	Santa Maria de Pandi	10,000

The total population before the insurrection was about 240,000, and the total area is estimated at about 226,806 hectares, or about 560,438 acres.

The industries followed are extensive cultivation of the soil, fishing (not only in the bay and in the rivers and their outlets, but also in every stream, including those of the mountains), the manufacture of hats, piña and jusi cloth, and to a very limited extent the cutting of timber and the mining and smelting of ore. The people are apparently fairly given to their respective labors, and, in general, good order and industry reign throughout. Prosperity has not yet returned to the province, and a large proportion of the people are miserably poor. It is hoped, however, that with the natural resources, with continued and increased industry, with the possible influx of better and more economical methods, and with the present excellent government, good order, and peaceful conditions, this province, so favored by nature and man, may soon find itself blessed not only with peace but also with prosperity.

GEOLOGICAL.

The delimitation of the geological boundary lines in the Province of Bulacan has not yet been accomplished, for the reasons that, up to the present time, very little purely geological work has been done in this province; and the greater part of the fragmentary evidence at hand relating to this area has been obtained in connection with objects other than the particular study of Bulacan.

The very small amount of material bearing on this subject and available for review, has been translated by me from various pamphlets, monographs, and records in Spanish, forming part of the archives of this Bureau. These included papers and reports by Centeno and Abella, who were eminent engineers and geologists of the Inspección General de Minas, and extracts from the writings of the foreign travelers and explorers, Itier, Semper, and Dr. Richard von Drasche.

In his interesting monograph upon the Taal Volcano, published in Madrid in 1885, Señor José Centeno, Inspector-General of Mines for the Philippines, has the following to say under the section "Prehistoric Eruptions":

"The narrow limits within which is comprehended the history of this country, not exceeding three hundred and fifty years, do not permit an account being given of the great vicissitudes and metamorphoses which this region has undoubtedly suffered, if we take into consideration the special circumstances which concur in it. First, on account of its situation submerged in the midst of a deep lake so near the sea and only separated from it by a narrow border of land composed exclusively of volcanic products; secondly, because of the great area covered by these products, which appears to begin from this volcano as a center and to extend south to the sea, and north as far as the town of San Ildefonso in northeastern Bulacan, distant 115 meters (71.5 miles), constituting a small isthmus which separates the Bay of Manila from Laguna de Bay; so that the volcanic tuffs thus constitute without interruption the soil of a great part of the area occupied by Bulacan, Cavite, Laguna, and Batangas Provinces. This great area covered with volcanic products probably thrown out from Taal, reveals a prodigious activity in remote epochs, historically speaking, since no tradition concerning it was known by the inhabitants when they were first conquered, but in modern times, geologically considered, since these tuffs lie above the latest Tertiary formations appearing in various points in northeastern Bulacan, and made up for the most part of coralliferous limestones which serve as the separation of the two formations—the volcanic of the plains and the crystalline of the cordillera.

"These immense deposits of volcanic tuff * * * attain considerable thickness in some places, forming superimposed beds of analogous elements, but of distinct structure, which indicate by their relative thickness and by the disposition and form of their components, the importance and the nature of the successive eruptions of ashes, pumice and volcanic detritus which in general constitute them. We have seen the tuff amount to a depth of 31 meters (102 feet) in some of the excavations recently made for the waterworks of Manila, the various beds being separated by other thinner layers of fine-grained sandstones, which were undoubtedly formed by aqueous sedimentation during the intervals of repose of the volcano. The considerable extent of said tufaceous formation, as also the notable thickness found in some places, make one suspect, with reason, the more or less remote existence of a great volcanic focus, of which perhaps the islet, partly submerged, which to-day constitutes Taal, would be some slight remains. This hypothesis has been already proposed by Padre Martinez de Zuñiga, who explained the existence of the deep lake of Bombon by the submersion of a great volcanic mountain; and F. von Hochstetter, according to von Drasche, adheres to the opinion

of Padre Zuñiga, putting it more concretely in the following paragraph:

" 'This crater, although it is elevated now, is not higher than the base which remains of a volcanic cone long since submerged, which must have had an altitude of from 8,000 to 9,000 feet, and must have been the highest in Luzon, the Lake of Bombon and the present cone of eruption having been formed after the sinking of the first.'

"The Padre Buceta adopts also, in his Geographic Dictionary, the hypothesis of Padre Zuñiga, giving it, we know not with what authority, a certain character of being historic, in the following paragraph, which with the idea of describing the different eruptions of Mayón in Albay, and of establishing comparisons with Taal, asks:

" 'Would it be wondered at if the vicinity of this volcano (Mayón) should come to be reduced to a lake, as happened with the other in the Province of Batangas, the mountain being submerged without leaving above the waters more than a volcanic island?'

"Finally, the illustrious geologist, von Drasche, whose excellent treatise upon Luzon we have frequently cited, without daring to adopt absolutely this hypothesis, expresses himself, nevertheless, as follows:

" 'I have never succeeded in finding out if so great an event (the sinking of the old volcano) has taken place in an epoch in which the Philippines were inhabited; but I have as security that the porous tuffs which are found in all parts (in the region of central Luzon) correspond to eruptions of this old volcano, it being possible that some day there will be discovered data among them, partly by paleontological, partly historical, which will solve the question.'

"After such authoritative opinions, with those which essentially confirm the hypothesis, we can add but little upon this point; we shall present some additional observations, nevertheless, which, being pertinent, tend to support the hypothesis.

"The situation of the Laguna de Bombon, separated from the Bay of Balayan by a narrow stretch of volcanic tuff of slight elevation above the level of the sea and of modern formation, indicates, therefore, that before the last eruptions of the volcano formed this dike the waters of the said bay penetrated as far as the site occupied to-day by the lake; and that here lies the rational and logical explanation of the marine fishes (Note 1) left in it, and of the plants of the seashore. * * * Therefore, if account is taken of the small present focus, with the insignificant altitude and the historical eruptions of which we know, and if we can not find a sufficient explanation of the existence of such extensive and deep volcanic formations as we have cited, it is natural to suppose, as Hochstetter did, that another volcanic cone existed, of greater dimensions, because its eruptions and showers of ashes and cinders, reaching greater altitudes, could have been impelled by the winds and have fallen over a greater extent in the neighborhood of the focus. It is not possible to fix now, in a definite manner, the altitude of this cone, nor to assert that it was

the highest in Luzon; but its situation can be fixed, perhaps, if the form and contour of the mountains now about the volcano be taken into account. It is an observed fact that Mount Macolod, 966 meters (3,168 feet) high, slopes toward the lake so rapidly that it appears to indicate great separation, disengagement, and slipping of the rocks which constitute it; and further, that the opposite slopes, toward the great mesa of volcanic tuff, at 300 meters (984 feet) above sea level, are less abrupt and it is only near the summit that indications of slipping are seen. All the great mesa which extends from one side or the other of Mount Macolod terminates similarly at the lake in an abrupt manner, presenting steep and almost inaccessible slopes, indicating here also the probability of slipping or abrupt submergence like those of the western slopes of Macolod.

"If we observe the opposite part of the lake we shall see that the cordillera called Tagay-tay, which is limited to the north and terminated toward the east by Mount Sungay, has also its southern slopes of rapid fall, and at some places in the border of the lake appear great escarpments of 20 meters (66 feet) and more of altitude, that are almost vertical, as at Mahabangbató, in Banga, and at Balitbiring, in Caloocan, in which the horizontal strata are very clearly seen, indicating also that said escarpments have been formed by the sinking of a part of this formation whose surface of slipping or fracture is the same escarpment; further, that on the northern slopes, which form the territory of the Province of Cavite, the ground falls smoothly and without noticeable break from 500 or 600 meters (1,640 or 1,968 feet) of altitude, which the cordillera attains, to the level of the Bay at Manila. If we imagine a section passing through Mount Macolod and the present crater, reaching to Manila Bay, crossing the Tagay-tay Cordillera, we shall see graphically represented the above observations; and, following this hypothesis, if we prolong the lines which can be considered as remnants of the slope, we may hazard a restoration of the ancient volcano. * * * There would result in this manner a volcano of great dimensions, whose circumference at the base would measure not less than from 90 to 100 kilometers (56 to 62 miles, somewhat less than that of Etna), and whose altitude, on the supposition that there were no great irregularities in the inclinations of the slopes, could be placed at some 3,750 meters (12,300 feet). It is not pretended, even remotely, that such figures would be even approximate, but it can not be doubted that the supposed volcano must have had very great dimensions if we take into consideration the great extent and notable thickness of the formations of tuff which have been ejected from its interior.

"If we suppose an average thickness of 15 meters (49 feet) for this formation whose surface, without counting the part at the present time submerged in Manila Bay and the Mindoro Sea, is approximately 2,800

square kilometers (1,081 square miles), there would result a volume of material ejected by this volcano of 42 cubic kilometers (10 cubic miles), besides that corresponding to the unknown marine part, and the great quantity of ashes and cinders, in an extreme state of division, which could have been carried by the wind to great distances without giving place to true beds of sediment. All of these added volumes would produce consequent voids in the interior under this great cone, and the natural depression or submergence of a great part of it in one or many epochs, more or less apart.

"It should not be surprising that such great quantities of material should come from the interior of the supposed volcano if we take into account that the volume of such a cone, supposing it to be solid in the interior, and with a base corresponding to the diameter of the present lake, that is about 20 kilometers (12.4 miles) would be

$$Ar^2 \times \tfrac{1}{3}h = 3.14159 \times 10^2 \times 1.250$$
$$= 392.7 \text{ cubic kilometers} = 93.5 \text{ cubic miles},$$

which figures give easily the 42 cubic kilometers (10 cubic miles) of the visible formation and such others as may be submarine, sufficient of it remaining for the conical crust which the volcano would form before submergence.

"It would be interesting to mark the limits with more or less exactitude of the epoch of such prodigious activity of this volcano; and to that effect, from the moment when they began the extensive excavations it was necessary to make in the volcanic tuff for the Manila aqueduct, I begged my dear friend, Señor D. Genaro Palacios, the engineer in charge of those works, that he might give orders to his overseers to collect with greatest care all animal fossils which might be encountered, and I myself have frequently inspected the sections scrupulously, but unfortunately up to the present no animal remains have been encountered. On the other hand, there abound notable vegetable fossils, tree trunks more or less perfectly silicified, and clearest impressions of leaves and branches, those which we have been able to determine up to the present belonging to the present flora (Note 2); but I have been unable to find in any of these any vestige of the hand of man, either in the felling of the trees or in artificial forms. Perhaps more assiduous and continued investigations can result in discoveries of this kind, which will reveal to some extent the character of the life of this region; in the meantime, with the data collected up to the present (1885), there is reason to suppose that during the long period of formation of this volcanic tufa the country was almost deserted, or at least that those who peopled it were of such a nature that no remains of them have been preserved in the beds of ashes and cinders which enveloped them.

"NOTE 1. There still remain sharks, according to the natives of the locality, which do not leave these waters.

"NOTE 2. I possess silicified samples of trunks of *Streblus asper, Louvina* (*Calius* of Blanco), leaves of *Psidium guyava,* and the impression of a piece of *Cambu,* gifts from Fr. Celestino Fernandez."

Thus we have presented what I shall call the Zuñiga theory of the Taal Volcano, and this matter is of interest to us here because, whether or not it explains the early history of Taal, the extensive deposits of volcanic tuff in Batangas, Cavite, Rizal, and Bulacan are, at least partly, thus accounted for.

My own notes and observations in these provinces tend to the belief that Taal was unquestionably at a prehistoric period very high and of tremendous activity; that it stood partly surrounded, if not wholly, by a stretch of the sea extending from the Gulf of Batangas to the Lingayen Gulf; that during its activity large quantities of volcanic ejecta fell into this inland sea forming the more or less stratified deposits of tuff now furnishing much of the rich soils of the Provinces of Batangas, Laguna, Cavite, Rizal, and Bulacan; that an explosion, or a series of them, blew out the entire upper cone, leaving the rim of the present boundaries of the Lake of Taal; and that subsequently minor cones were formed and this region was gradually raised to its present level.

A number of points of similarity between the Volcano of Taal and that constituting Barren Island, in the Indian Ocean, present themselves, and it does not seem at all unlikely that these two exceptionally low volcanoes, that are now but most unsightly remnants of their former cones, may have passed through similar mighty cataclysms to result in their present similar forms.

The Taal Volcano will form the subject of a later report in which all information attainable will be presented, revised, and with photographs.

In connection with the three fossils mentioned in note 2 above, I would state here that I find two of the trees (*Streblus asper* and *Psidium guyava*) in the lists of trees that may be felled under regulations of the Forestry Bureau, and one of them (*Psidium guyava*) is on the list of those I observed standing in Bulacan. They are decidedly modern!

The above extensive quotation also illustrates the fact that we must sometimes go far afield for geological data by which to arrive at conclusions concerning a fixed area. The Taal Volcano is in south central Batangas; the tuff deposits of Bulacan are in the south central portion of that province, lying between an alluvial belt of most modern period, geologically, which forms the flood plain of the Rio Grande de Pampanga, including the Candaba Swamp, and which borders the bay shore of Bulacan, and the sedimentary deposits of limestones and shells mentioned above of late Tertiary or Quaternary age, which rests upon the core of the foothills and of the cordillera, and which extend partly into the plain. The northern limit of this tuff deposit is at San Ildefonso, and the eastern limit curves from a point about halfway between San Rafael and Angat southeast to San José del Monte, and from thence beyond

the province in the direction of the Island of Talim in the Laguna de Bay.

The data for the final age determination of these areas is not yet at hand, and much remains to be done, not only in Bulacan, but in the entire region of central Luzon, before the geological map is possible.

The plain of central Luzon I believe to have been very recently a shallow sea. Upon this point and also in connection with the tuff deposit of Bulacan, we have the following by von Drasche, from his "Data for a Geological Study of the Island of Luzon," a copy of which, in Spanish and corrected by Abella, is in this Bureau:

"From the geological data which are available to-day of the sierra (Zambales), it is difficult to distinguish the point of origin of the great eruptions producing the material, which, transported by water, have formed the extensive beds of trachytic tuffs; no doubt in the least remains, however, that those which cover the Pampangan plain took their origin in a shallow sea; and, although I have been unable to encounter any fossil remains in these beds in spite of my most careful investigations, these remains have nevertheless been seen at various points.

"Itier, for example, mentions them in his 'Fragments from a Diary of a Voyage to the Philippines,' and in speaking of the numerous masses of pebbles in the Angat River says:

" 'It is evident that the deposit of loose lacustrine rocks is, as has been said above, anterior to the appearance of the present volcanic phenomena; and to the disturbance produced by these last it is doubtless due that the waters of the lake ran to the sea, conveying a part of the accumulated pebbles of the lake bed, and furnishing materials which, upon being mixed with volcanic remains, constituted the surface of the vast plain of Bulacan, whose subsoil, composed exclusively of volcanic tuff, had been formed in the basin of a sea which became filled, thus explaining the presence of numerous marine shells existing in a fossil state in the peperino of the subsoil of Bulacan.'

"Semper also speaks of this in his sketches, saying, 'in the central plain of Luzon, which in its highest point is somewhat less than 150 feet above sea level, according to the observations of Father Llanos, there is found in many places below the thin stratum of clay, a marine sediment; and in some places, in the Province of Pangasinan, to the north of Angat, there are seen lakes of salt water in which should still live mollusks, the same as in the salt or fresh rivers of the same province.' "

It seems more than probable that these theories, and the fragmentary evidence, though I have been unable as yet to find final confirmation of its value, will eventually lead to the establishment of some such geological scheme as the following:

First. At the end of the Tertiary the plain of Bulacan was submerged and formed either an extensive salt lake, a shallow sea, or an open chan-

nel, the Zambales Range to the west rising from the waters as an elongated island extending from Cape Bolinao to Mount Mariveles, Mount Arayat standing a solitary volcanic islet in the midst of this sea, and the cordillera and the higher foothills now forming the eastern part of Bulacan, separating this sea from the Pacific and forming part of the Luzon of late Tertiary times.

Second. In the clear waters of this sea corals were living and building the coral reefs, some of which are now found in the form of the range of limestone hills running parallel to the cordillera, to the west of the main range, and extending from the southern part of the province through the Bocol and Baras-bacal hills, Mount Tucod, Biac-na-bató, the range at Sibul de San Miguel de Mayumo, and beyond the province in similar manner to the north.

These corals died from the muddiness produced by river or volcanic sediment, or from the disappearance of the sea by the elevation of the land.

Third. During this period the Volcano of Taal was very much higher than it is at present and this, and probably other volcanoes, were very active, ejecting volumes of cinders and ashes that fell into the inland sea, and were transported and deposited in the form of peperino, or volcanic sand, covering parts of the present Provinces of Bulacan, Cavite, Laguna, and Batangas. During the intervals of repose the thin beds of sand and clay were deposited which to-day mark the distinct layers of tuff in some places.

Fourth. In the Pliocene or Quaternay there were violent volcanic disturbances that resulted in the submergence or explosion of Taal, the flexure and folding of the strata flanking the cordillera, contemporaneously with the flow of the modern andesites and trachytes.

Fifth. The elevation of the plain beginning probably in the Pliocene, with the exception of the extensive Candaba Swamp which is still but little above sea level.

The evidence, such as I have been able to gather in the field and from the records, points to some such sequence as that given above.

As for the Eocene, or earliest Tertiary, I was able to find no sign of it, as indicated by fossils, during my field work; and nothing has yet been found by me in connection with this epoch in Bulacan in any writing I have seen. The *nummulitic* limestone of Cebu and of Binangonan (the latter in Rizal Province just south of Bulacan) has been the criterion for this epoch in the Philippine geology. But, although I searched diligently for the *nummulites* in the limestones, I found no signs of them at any time. The few very imperfect fossils I observed in the limestone of the tilted strata in the Bayabas River, just above the Santa Margarita spring, were unrecognizable beyond the fact that from their form they could never have been *nummulites*. On the other hand, I found a fossil coral,

not yet determined, in the limestone rock on Mount Balite, near La Mesa; Itier and Abella and Centeno mention the *madrepore* corals in the limestones.

In connection with the above I quote from the paper by von Drasche, previously referred to, again:

"We should then distinguish in Luzon, up to the present time, two separate limestone formations:

"First, the Eocene, rarely found, in small isolated beds.

"Second, the modern coralliferous limestones, of great extent, from the north to the south of the island.

"Returning then to the consideration of the terrain of the San Mateo River, as the pebbles are in greater part of syenite, diorite, etc., and as there are but few of trachyte, it can be deduced that the mountain of San Mateo with some exceptions of signs of trachyte, is composed of the older rocks, similar to those of the Zambales Sierra, a fact confirmed by the observations of Itier and Jagor.

"The former says: 'In Angat, at the foot of the promontory of the cordillera of Luzon, there exists no sign of the volcanic products and the pebbles which the river carries are of diorite, syenite, *espilita* (?), epidote, and porphyry.' Afterwards he adds: 'There is magnetic iron near Angat, and limestones lying in vertical beds and containing *Madrepores, Ostreas,* and *Echnoids.*' "

In the "Descriptive Memorial of the Mineral-Medicinal Springs of the Island of Luzon" of 1885, by the commission of which Centeno was the chief, he says, concerning the San Rafael spring of San Miguel de Mayumo: "Great beds of clay and alluvial detritus form the soil in which appear the *madrepore* limestone which constitutes the geological formation of the hills of Sibul;" and in connection with the San Mariano spring of Norzagaray, he adds: "The greater part of the soil comprehended between the barrio of Matictic and the springs is formed of alluvium, through which appears in places crests of metamorphic rock. Upon reaching the Mabató Creek very hard and compact limestones are seen in which are distinguished, with some confusion, *madreporic* remains, being precisely in this rock, analogous to that which constitutes the Sibul (San Miguel) hills, that the appearance is noted of the mineral spring, upon the right bank of the creek and similar so that of San Rafael. Across the creek, and at a kilometer (3,574 feet) approximately from the right bank lies a limestone range, running in this region from southeast to northwest, and which, without any doubt, is the prolongation of the Sibul range."

I found these limestones mentioned above, at various points along a line aproximately parallel with the western flank of the range. They lie above sandstones and shales, as observed on the exposures of the Bayabas River. This formation, shown in accompanying photographs, dips 26° S., 51° W.

The layers of limestone are from 2 to 4 feet thick, are regularly jointed, and the joints show the effects of erosion to a very marked degree. Among the thin beds is a light cream-colored argillaceous limestone, which shows indications only of imperfect fossils. This exposure is found on the south bank of the river, just above the Santa Margarita spring, and is almost a right section of a portion of the Bocol-Barasbacal hills, cut here by the river. Heavy vegetation covers most of the rock; and immediately west of the tilted strata lies the massive limestone which is most commonly found along this limestone line running through the province. The juncture of this with the thinner beds I could not satisfactorily locate on account of the vegetation and forest growth, but there is every reason at present to believe the beds conformable.

The sandstones and shales lie beneath the limestones and cutting these, and with them in many places lie the modern volcanic rocks, andesites, and trachytes.

Along the line of juncture of the limestones with the volcanics I found the mineral springs of Bulacan. These may be grouped under the heads, those of Norzagaray and those of San Miguel de Mayumo.

In his introduction to the "Descriptive Study of some Mineral Springs of the Philippines" Abella writes:

"In the central plain of Luzon, notwithstanding its rather limited area, the mineral springs are only found at the foot of the cordilleras which limit it, or in the neighborhoods of the volcanic focii which rise in its center, and they constitute two independent and well-defined groups, the eastern related to the cordillera which here is the divide from the Pacific, and the western to the Zambales range.

"The eastern group sometimes outcrops from the heart of the early diorites and diabases within the cordillera, and sometimes from the post-Tertiary beds which lie upon, and are elevated by, the trachytes and andesites.

"It is believed that these modern rocks of a volcanic character, upon lifting the strata of the post-Tertiary formation and crossing them in many places, have produced in them foldings, faults, and other geological displacements which have been able to facilitate the hydrothermal mineral emissions and those of the gases which occasionally accompany them; so that certainly an *a priori* argument can be announced that the mineral springs thus originated should be found in lines approximately parallel to the directions of the anticlinal and synclinal axes of these beds and to the trend of the cordillera upon which they lie. Thus it is, as a matter of fact, and the springs of Sapang Mainit in Pantabangan, of Sibul in San Miguel de Mayumo, and of Sibul in Norzagaray, occur in a right line running north and south, approximately parallel to the direction of the cordillera and to that followed by the outcropping of the beds of conglomerates, sandstones, slates, and limestones which constitute the said post-Tertiary formation of the center of Luzon.

"The springs in the interior of the cordillera, though not completely studied in their greater part, are found in the heart of the older rocks which constitute the range, and they can have been originated by the eruptions of diorites and diabases which are also found at those places, although we certainly must admit the possibility that the faults and paraclases produced by the eruptions of these diorites and diabases, which would serve to conduct the hydrothermal mineral emissions of these epochs, might have been removed and modified by the recent eruptions of trachyte and andesite, the thermality and the composition of the waters which circulated through them being also modified. It is very difficult, in fact, to imagine an absolute and permanent quiet in the regimen of the thermo-mineral waters of dioritic or diabasic origin, since they have been subjected, in the region occupied by the Island of Luzon, to volcanic and seismic phenomena so potent and general as those which are observed and noted to-day all over its surface."

In my observations in the field I found numerous instances of violent twisting, fracture, and faulting, due in part, at least, to volcanic action and to these andesites and trachytes that form the modern eruptives. Along the Bayabas River, for instance, in several places the stream is choked with tumbled masses of great limestone bowlders, fallen into it, and broken from the strata on the hillsides above; the strata themselves are violently fractured and displaced, the shales further up the stream are twisted and faulted, and between La Mesa and Bayabas the streams flow at various angles over the synclinal and anticlinal axes of the strata; there are frequent evidences of marked extrusions of andesite and trachyte, and, finally, the escarpments of such cliffs as are seen at Mount Balite, and at points above Bayabas, tend to the belief in extensive displacements, faulting and slipping of the entire strata, leaving more or less gradual and regular slopes upon the west and abrupt faces to the east and northeast, certainly not to be ascribed entirely to the effects of erosion.

The Angat and Bayabas Rivers are two characteristic streams of Bulacan, rising in the cordillera and finding their ways through the foothills. These streams all bring down from the sides of the higher hills and of the main range great quantities of pebbles and bowlders of massive crystalline rock. The beds of all the mountain streams that I saw in Bulacan are strewn with these pebbles, and they indicate precisely what von Drasche supposed when he read the statement already quoted of Itier of like effect, viz, that just east of Angat in the higher hills and in the cordillera, lies an area of the older crystalline massives. During my tours in these hills I found these rocks in place, thus verifying that portion of Mr. von Drasche's geological sketch map of Luzon whereon he laid down an area of the crystalline rocks in what corresponds to eastern Bulacan. The map referred to, which accompanies the "Data for a Geological Study of the Island of Luzon," and which is on the extremely

small scale of 1: 1,666,666, contains a number of errors and inaccuracies which perhaps could not be avoided with the means at hand nearly thirty years ago, when this interesting paper was written. My observations of crystalline rock of Mount Calabaza and Mount Pecote, and the Sapa-Santol, Sapang-Bacal, and Maon Creeks, therefore, do not verify the boundaries of the crystalline area of Mr. von Drasche, but they *do* verify the supposition of the Austrian geologist that crystalline rocks lie in place within this area. No mention is made that either Itier or von Drasche ever entered into the hills wherein lie the massives; Centeno and Abella visited the mines, but so far as I know their visits were confined to the mines and were a matter of but a few days, or the time necessary to make their official inspection. In my own case the mines were my objective point; but I gave what additional time I could to the collection of samples of the rocks of this region. My specimens of these and other rocks have not yet been afforded the time and facilities for microscopic and bulk analyses, and they have been subjected merely to my own megascopic analysis. The lithology of these rocks will therefore be held for future reports upon the geology of the cordillera; among them, however, I mention here several specimens of fine-grained diorite, somewhat similar to the rock of Nueva Viscaya (Aritao, Camarin Santa Clara), called syenite by von Drasche, and diorite by Abella. I am not sure, however, that Abella saw the same rock of which von Drasche writes. We have in our Bureau museum a sample classified as "syenite" from the precise locality von Drasche mentions, and it certainly appears to me that it is not a syenite, but a quartz-mica diorite or tonalite; and as Abella mentions the tonalites of Panay, I should be surprised if he should call the rock found by von Drasche a diorite (if he saw it), without further modification. Of course the determination of the feldspar, and the microscope will settle this question of the syenites and diorites. Until the final distinction be made I shall call this fine-grained rock with hornblende, and a feldspar that certainly appears to be a plagioclase, a diorite. Two other coarser-grained crystalline massives also from Mount Calabaza and Sapa-Santol, are partially decomposed, and a fourth found in place on Mount Calabaza, is a compact, extremely tough and firmly cemented mixture of quartz and feldspar, without hornblende or mica, and this I shall call provisionally granulite. Another crystalline rock represented by an immense weathered spheroidal bowlder about 12 feet in diameter, resting in a saddle in the Mount Pecote range, seems to be, from its composition and structure, a gabbro. I was unable to find this rock in place during a diligent search on the ridge and slopes of Mount Pecote and elsewhere, and beyond the big bowlder partly sunk in the ground I found only one or two smaller ones in the immediate vicinity. These are old, covered with a thin crust of weathering, giving them a dark-brown color. The deposit of laterite or decomposed rock in place, is thick here as elsewhere, and the vegetation is as heavy as usual; so that

the obstacles preventing satisfactory exposures are not less evident here than elsewhere in these Islands.

In passing, I would state that a fine rose-red trachyte found between Mount Pecote and the Bocol hills is very similar to that found in a corresponding position to the cordillera in Nueva Viscaya. In fact, judging from all evidence, the western flank of this main divide probably evidences the same conditions through the Provinces of Bulacan, Nueva Ecija, and the southern part at least, of Nueva Viscaya. The massive crystalline rocks of the core of the cordillera are likewise similar, if not the same, not only by inference, but from the evidence of all rock specimens at hand.

Before adding a few notes upon the subjects of fossils and limestone caves, I shall make the following brief summing up:

In Bulacan we find, first, the pre-Tertiary crystalline massives of the higher foothills and of the range; second, the modern volcanics, with, third, the late Tertiary or early Quaternary sedimentary rocks; fourth, the tuff deposits of the plains, of recent period, and, fifth, the alluvial belts of the present along the river beds and the bay shore. In the above arrangement according to time we also have roughly an arrangement proceeding from the ridge of the cordillera westward to the shore of Manila Bay.

Some brief mention has been made in the foregoing pages of the fossils of the rocks and deposits of Bulacan. Unfortunately, the evidence at present is extremely meager and unsatisfactory. Age determinations must therefore wait until time and facilities are afforded for careful study of the cordillera, the Zambales range and the great plain of central Luzon. Paleontological work during my recent brief survey was limited to search for fossils during the few days available from other demands. I was particularly attracted toward the tilted limestones and twisted shales of the Bayabas River, but in them I could find nothing of value as fossils. In the records and in the museum of the Bureau I have also been disappointed in my search for paleontological evidence, although to former investigations in fields near by I must acknowledge indebtedness for information that throws light upon our problems here. To Mr. K. Martin, for his work on the "Tertiary Fossils of the Philippines" and to Mr. G. F. Becker for translating and presenting it, and for the suggestions in his valuable report[1] I am especially indebted. The complete bibliography of the geology of the Philippines has not been accessible to me, but to Mr. Becker's résumé of the information readily available to him in Washington I am also greatly indebted as I have been able to use one or two foreign contributions through him that were not available in Manila.

In summing up it may be stated that but one fossil remains has yet

[1] Report on the Geology of the Philippine Islands, United States Geological Survey, 1899-1900, Washington, D. C.

been found that points to an age in the Bulacan strata even as old as the Eocene. This statement does not imply that older strata do not exist; on the contrary, I am strongly of the opinion that they and older rocks will be found, greatly contorted and displaced perhaps by the post-Eocene upheavals. As for the crystalline rocks, there is no evidence as yet to prove that they should not be found to belong as far back as the Palaeozoic; and we may eventually find parts at least of the intervening Mesozoic strata, here, as elsewhere, adjacent to the crystalline core of the main ranges. Miocene and Pliocene strata are not definitely known by their fossils in Bulacan, and indeed very imperfectly in the Archipelago. I have therefore referred to the later Tertiary and the Quaternary in the foregoing pages, but the distinctions even between these are not definite.

From the history of the coral limestone of other parts of the Islands I have assumed that they may be assigned to the later Tertiary *or* the early Quaternary. The dividing line has not yet been established. The fossil shells of the plain of Bulacan are all of animals now living in the warm seas adjacent to Luzon. The corals of the limestone so extensively developed are also modern. And the only vegetable fossil that I have heard of from this province is one that I found enveloped in a water-worn pebble about the size of a lemon. Upon breaking the pebble to learn its composition I found a vegetable fossil. This has been referred to Dr. J. G. Coulter, expert botanist of the Educational Department, who has provisionally classed it as the staminate cone of a Lepidodendrid! This find is most interesting and important. If the fossil prove to be a Lepidodendrid, we have here a most pointed suggestion that the early Mesozoic, or the Palaeozoic, will yet be found in the Philippines. Final determination of this and other fossils will form material for later report.

The limestone caves of Bulacan deserve rather more than passing mention. They are found in the coral rock extending, as mentioned before, through the province. They are formed, it is hardly necessary to state, by the water courses which originally flowing through the fissures of the rock dissolve the calcium carbonate and so enlarge the passageway, forming immense caverns. The dripping of the impregnated waters through the overlying calcareous formation and through the roof leave by evaporation the stalactites hanging from above and frequently form stalagmites on the floor. The bottoms of the caves are usually waterways, and contain pools more or less extensive, and they are frequently streams with pebbles, sand and mud. The tendency of the waters of the stream, if it be swift, is to dissolve and erode and so to enlarge the caverns; if it be slow to dissolve but also to deposit sediment; and the tendency of the percolating waters is to form stalactites and stalagmites if highly impregnated with mineral matter in solution, and to increase the width of the fissures and opening if but lightly charged. Therefore, limestone caves may remain of constant dimensions, theoretically, although this

accident of the equation of agencies is of course very rare; or they may be constantly or intermittently enlarging, or becoming filled, depending upon the relation between the amounts substituted or removed.

In Bulacan there are numerous caves from San José del Monte on the south to the Madlum Cave on the north. They are all of similar origin but of varying size. The most famous of these caves is the historic Biac-na-bató, which gave its name to the Treaty of 1897 between the insurgent and Spanish forces, and which was an almost impregnable fortress, frequently sheltering large bodies of insurgent troops. A photograph of its entrance appears in the report of the Schurman Commission to the President for 1900. The peaks of Biac-na-bató rise, rugged and prominent, from the plain of Bulacan. The cave of Madlum is shown upon the sketch map of the Sibul of San Miguel de Mayumo. There are two caves to the southeast of Norzagaray, the exact locations of which I could not learn, one of which was described to me by Lieutenant De Court, who states that it is very extensive, contains deep lakes of water, and is the home of thousands of bats which fly out in such vast swarms when disturbed that the visitor must protect his face and body from them; and the other, described by my guide, Fajardo, is also very extensive, but it is never visited by the superstitious natives who believe it to be haunted. I found time to see two of the well-known caves, one of them in Mount Tucod, on the southwest side of the Pangisijan Creek, and the other, the cave of the Punings, near the barrio of Bayabas.

The Tucod Cave, called by the natives the iglesia, or church, consisted mainly of one large room about 50 feet high, from 40 to 80 feet broad, and about 75 feet deep. It is entered from the bed of the creek through two large arched doorways, and clefts run through the roof to the top of the limestone hill separated from Mount Tucod by the gorge cut by the Pangisijan. There is a tumbled mass of rock resembling an altar and great, beautifully colored stalactites, reds and greens, resembling candelabra. The floor is covered with loose sand, pebbles, and bowlders. The cave is self-ventilating in the same manner as are some mines worked by both shaft and tunnel. The cave is constantly enlarging, and from erosion and dissolution of the calcium carbonate by the rain water from above will eventually be open to the sky.

The cave of the Punings is the most interesting and extensive, probably, in the province. It is shown upon the map and is illustrated imperfectly by the photographs accompanying this report. The Sapa-Santol, or Santol Creek, as shown upon the map, rises near the Santa Lutgarda claim, flows around the base of Mount Calabaza and flowing *through* Mount Puning, changes its name to Puning Creek and discharges into the Bayabas near the barrio of Bayabas. This, like all of the mountain streams, flows through narrow valleys with extremely steep sides, and it carries little water in the dry season, but it is a rushing torrent during

the rains. The formation of Mount Puning, which is almost a conical hill, is of coralliferous limestone. The stream, in ages past, found a fissure through the rock and has gradually cut for its waterway a cave over a mile long. The entrance from the Bayabas is a singularly pretty and attractive one. Leaving the Bayabas one follows the Puning Creek upstream, over distorted shales overlaid by limestones, past little cataracts, waterfalls, and deep pools, all overarched by tall trees and climbing vines; and, after following the little valley to the right, one comes into a little open space and is confronted by the side of Mount Puning, rising almost vertically for 50 or 60 feet, and here is the entrance to the cave. The stream has disappeared some distance below, and during the dry season one walks over the sand and pebbles of the creek-bed of the rains. For about 400 feet and in the direction S. 70° E. there is a great cathedral-shaped cavern, about 80 feet broad in some places and the point of the arch 150 feet high in many places. During the dry season the water runs beneath the pebbles and sand and the upper floor is almost dry. The bed inclines at a slight angle over this stream bed, the inclination being much more abrupt near the head of the main cave, where there are bowlders and great blocks of the limestone in place. This part of the cave contains many beautiful stalactites hanging from the roof and sides, some of them of greenish and reddish tints and some of them sparkling with millions of little crystals of calcium carbonate. One great stalactite, the Giant, is almost the shape of an inverted turban, and chokes the passage at the point where it hangs, about 400 feet from the mouth. At this place there is a narrow passage running to the northeast, and another, the main passage, running 24 feet to the S. 20° E. 13 feet S. 65° E., and 18 feet S. 30° E., at which point there are many bowlders, a steep incline, and a large almost perfect basin of marble, containing clear water. The sides of the cave here are of a beautiful bluish mottled marble. The incline becomes more steep and difficult from this point, and finally, about 75 feet farther, the passage is very slippery and narrow, and here we stopped, our large supply of torches being about spent. The entire length of the cave is something over a mile, and my guide told me that men have been lost in it for two days. The rock floor is covered for the most part with sand, pebbles and bowlders to the depth of many feet. I found no signs of life of any kind excepting one remarkable spider previously mentioned, and one large black frog. The only fossil observed was a portion of a madrepore coral, broken by me from the rock at the side of the cave. A fairly strong current of air sweeps through the cave in the direction of the water flow, and the coolness, dampness, darkness, and the draught of air, remind one strongly of conditions of a mine.

THE MINERAL INDUSTRY.

The mineral industry of Bulacan is at present confined to the mining and smelting of iron, the washing of the sands of the mountain streams for gold, and the calcining of limestone. Beyond these I could learn of no activity in this industry of any sort; and these, indeed, are now so extremely limited that they prove an exceedingly insignificant portion of the productive activity in this province.

The history of iron mining in Bulacan is of more than ordinary interest. Romantic incidents are related by Foreman and others, of which we have no records in the Bureau, and which will not be enlarged upon here. Of one thing, however, I am quite convinced—that some of the most interesting of all the chapters of the history of these mines are those missing from the records, echoes of which are sometimes heard from the natives of Angat, and evidences of which are seen in old abandoned pits, charcoal ovens, and slag dumps on the hills and mountain sides. Ruins of houses of the early ironmasters are also seen, and in Angat, Norzagaray, and other towns near by are still to be found old plates and bowls of cast iron which indicate that in the years gone by the scope of this industry was much broader than it is now. In connection with this subject I quote from Abella who says, in his "Brief Sketch of Mining in the Philippine Islands," published in Madrid in 1883:

"Next to gold this metal is the one earliest exploited in the Philippines. There exist abundant deposits of it, the best known being situated on the western flanks of the central mountain range of the Island of Luzon.

"Those deposits in the district of Morong were, in reality, first exploited for the purpose of manufacturing munitions of war; and presently those of San Miguel de Mayumo, and those of Angat, in Bulacan, were exploited for the manufacture of mountain knives (bolos), plowshares, and kitchen utensils. These articles were of excellent casting and quality, and were purely for local consumption. Later, at the beginning of this century, an attempt was made to establish a large plant for the exploiting and manufacture of this material, with large furnaces and corresponding machinery; but, as the exceedingly bad roads that this machinery would have to pass over were not taken into account, the enterprise failed even before the working of the mines was begun.

"According to the descriptions of engineers or competent persons who have had occasion to visit them, these deposits are unsurpassed, and they consist of masses, some of them of great extent, of red and brown hematite and of magnetite of excellent quality. Moreover, the situation of these deposits is such that in the immediate vicinity, or very near, may be found an abundance of wood for the manufacture of charcoal, and important supplies of water.

"Minerals of this class also exist in Paracale (Camarines Norte) in

Caraballo, in the Island of Cebu, and in some other points of the Archipelago.

"But there are only in actual operation some concessions of San Miguel de Mayumo and of Angat, with small furnaces, which manufacture knives, plowshares, and kitchen utensils, as we have indicated. It is to be hoped, nevertheless, that the exploitation of these minerals may be one of those industries to receive a grater encouragement at some future day."

The earliest record contained in the archives of this Bureau with reference to iron mining bears the date December 12, 1781, and is the letter-order of instructions to the "governor of Angat" through the governor of Bulacan from the Superior Government of Manila, to render every possible assistance to Chaplain Don Juan Belli, of the Royal Armada, in the working of his mine. This curious and interesting document is translated and presented in full in the report of the Chief of the Mining Bureau to the Acting Civil Governor *in re* the case of the iron mines of Angat. It seems that the chaplain was intrusted by the Government with the mining of ore and with the establishment of a smelting plant in the neighborhood of Angat, and that after entering upon the work he found it necessary to complain to the officials in Manila that the natives of his vicinity were unsatisfactory as laborers, and, more than this, that they were ruining the road he had built to the mines by dragging over it the timber they were cutting in the mountains. The reply to this complaint was the very spirited order referred to above, in which the governor of the pueblo of Angat is instructed to prevent the cutting of timber within a distance of 1 league from the mines, without express permission, to prevent the use of the mine road for timber haulage by these natives, and to insist that the justices of Angat and others respect the power given to the governor to enforce orders. In this "letter-order" from Señor José Basco to Señor Antonio Brioso, the importance of the development of iron mines is dwelt upon, and the instructions close with the following paragraph:

"It is indispensable that in the extensive development of these Islands, in all the departments of agriculture, arts, manufactures, and commerce, for all the inhabitants of them to put themselves into action with activity and vigor—a means by which, under the protection of God, we are about to extricate ourselves from the hands of a foreign commerce that is now overwhelming us."

Governor Brioso very thoroughly carried out his orders, and incidentally dealt with the labor problem of those earliest days of mining in a most interesting and decisive manner. He quotes the "letter-order" entire and then follows his proclamation, made from the Royal House of Bulacan, December 14, 1781. He instructs the governor of Angat to enforce the order under pain of fine and suspension from office for failure to obey; and the governor of Angat is further instructed to see that the

headmen of the *barangays* each furnish two laborers a month to the work of the mines and smelters, the men to be paid by the mine manager for their work and to be relieved monthly; all timber already cut is to be removed within twenty days, and after that no timber is to be cut or removed within a distance of 3 miles of the mine; the road is not to be used for haulage by the natives, and any damage done by removing the timber already cut is to be paid for by those causing the damage; and, finally, every assistance asked for by Padre Belli in the operation of his works is to be furnished by the officials of Angat as required.

These orders were published as certified to by the town clerk of Angat "* * * to-day, Sunday, the 16th of December, at 10 o'clock in the day, after the mass, in conformity with that demanded by the Decree of Obedience, which precedes, I caused to be published, and did publish the letter-order, in public and customary places, by means of the 'war-drum' and people of the guard, through the medium of said governor and the other officers in the presence of many and various people convened at said publication * * *."

Notwithstanding the plans and arrangements for the encouragement of the early iron industry, and the importance given to it, the next records show that it was not making the progress desired. In a second communication from Señor Basco to Governor Brioso we find the following, the receipt of which was acknowledged, and the original of which was forwarded to Angat, on the 3d of March, 1782:

"The chaplain of the Royal Armada, Don Juan Belli, who is at present directing the iron mine denounced in the territory of Angat, represents to me the little or nothing he is able to accomplish in his commission owing to the indolence and repugnance with which those natives assist in the labor of those works. This mine is of the greatest importance; not only to those who work, but also to the State and the public weal; since, without iron, as we generally find ourselves, it is impossible to possess agriculture, commerce, arts or manufactures; the construction of boats and edifices, for which, above all things, iron is the first requisite. The royal warehouses are devoid of this metal, of which increased amounts are needed on account of the large quantities used in the repairing of ships, works of fortifications, and the other equipments for sustaining war, and for the defense of these Islands; consideration being fixed on this, and also that it is not in the interest of any one individual (although it may appear thus, the interest of a private individual is not the moving cause in this matter), but rather the service of the King, the common good, and the defense of these domains; you will, therefore, inform yourself of the causes from which originate the repugnance of those inhabitants to the working of the mine, and you will inform me as soon as possible, endeavoring in the meantime to remove the obstacles that hinder a work so important, on the supposition that depending upon the well founded hopes of this superior authority in said mine, it has

failed to ask Batavia for the necessary iron supply, and we are about to find ourselves entirely unprovided if the mine does not produce the end desired."

What the reply might have been to this we are not informed; but we find next that the owner of the mine, who, it develops, was not the chaplain Don Juan Belli, but Señor Lorenzo Lopez de Buycochea, renter of the cockpits, asks permission to sell his mine because of his advanced age and because of the "accidents" not only to himself but to the director, Padre Don Juan Belli. This was referred to the judge-advocate, Royal Palace, Manila, May 14, 1784, and on the 17th the judge-advocate advised the Superior Government that there was nothing to prevent the sale, it being understood that the conditions of concession be assumed by the purchaser. On August 7, 1784, we find dated the deed of sale of the mine, works, and all property pertaining thereto, for the sum of 11,000 pesos, to Don Felix de la Rosa, lieutenant of the Battalion of the Royal Prince.

Upon the map accompanying this report at the head of the Pangisijan Creek will be found the site of the old smelter of Buycochea, marked as that of Felix of Valois; and the mine, as near as I can locate it from among the old abandoned workings, is near the place marked "Banca." So far as the records are concerned this pioneer iron mine of the Philippines was never named; and nothing is known of the dimensions of the property nor of the result of the workings, if even partial success was ever visited upon it.

The next that we learn in chronological order is that Don Santiago Hison, past captain of the Guild of Mestizos of Angat, petitions of the gobernadorcillo of Angat, that he be declared the discoverer of a mine on the Sapang-Bacal, and at a considerable distance from the mines of the late Don Felix de la Rosa, and of the Escalantes. (The latter mine is here mentioned for the first time, and is mentioned only in this connection. Its history, dimensions, and production are not known. Some evidences of old works in connection with it are shown upon the map.) On December 1, 1815, we find dated the order of the Governor-General of the Islands to pass the formal petition of Hison to the fiscal. This petition was undergoing the many processes leading up to the granting of possession, included among which were the summons to the mine-owners whose properties were adjacent to that asked by Hison, Don Juan de Escalante y Lazo, and Don Maximo de la Rosa, the former of whom wished his name withdrawn as the Hison mine could in no way be prejudicial to his interests, when we find the latter, Don Maximo de la Rosa, appearing in the Tribunal of Angat on February 19, 1816, and opposing the Hison claim upon the ground that he, de la Rosa, who had inherited the old Buycoochea mine from his father, the purchaser, had constructed a road for his mining project as

far as Sapang-Bacal, and at the cost of his yearly allowance; and that he objected to the use by Hison of the right of way. (This road I believe to be the mountain trail still the main thoroughfare in this region of difficult travel, which runs along the crest of a hill separating the waters of the Maon from those of the Pangisijan, on the right flank of which are found the most important iron deposits now worked in these mountains.) Then follows the summons to Don Maximo de la Rosa to appear for the examination, and his failure to do so, later explained in a second and very bitter opposition to Hison's petition, in which he claims that deceit and fraud had been practiced upon him. The petition of Hison went forward nevertheless; and as the Commission appointed to examine the sites of the mines had found and reported that a distance of 135 "brazos" (450 feet) intervened between the place where Don Maximo de la Rosa was taking out ore and the site of the Sapang-Bacal claim of Hison, as Don Juan de Escalante had professed no opposition, and as the various formal steps of the process were one after another complied with by Don Santiago Hison, we find that on the 25th of April, 1816, the commission appointed for the purpose demarcated the claim, 400 Spanish varas square, and placed Hison in possession, "causing the high constable to take him by the hand and walk with him the circuit of the premises, and in token of royal possession ('corporal velquasi'), a small piece of iron was given to him, in this act, and by means of the interpreters,' I ordered that nobody should venture to disturb said Hison in his possession, with which this official proceeding was concluded, and the assistants signed with me." This Hison Mine, although at present occupied by American prospectors, has descended to the great-great-grandchildren of the original owner, Doña Maria Alteza Fernando and her brother and sister; nothing further is heard of the de la Rosas, nor of their ancient claim; and Don Juan de Escalante y Lazo, whose mine and works are but barely mentioned, gracefully disappears from the history of these interesting mines of Bulacan.

The history of the remaining claims of Angat, "Santa Lutgarda," "Constancia," and "Sapang Munti," all among the present "first-class" claims, may be briefly summarized.

The Chinese ironmaster, Ong-Sayco, who has worked in the Bulacan smelters for over thirty years and who is to-day the "maestro" in charge of the new Constancia smelter, solicited on March 21, 1873, two pertencias, which *may* have been upon the site of the old Buycochea claim, although no connection is made in the records tending to substantiate this statement. Through faults of omission, and because of real or imagined conflict with other claims no concession was ever obtained by Ong-Sayco. On the other hand, his petition was united as an expediente with that instituted on September 9, 1873, by Don Quiterio Anchuelo

Rodriguez, for four pertenencias to be known as the Santa Lutgarda Mine. Neither Ong-Sayco nor Don Anchuelo gave precise boundaries or descriptions in their petitions, but it is believed that they both struggled for the same deposit of ore—which lies just south of the old Hison claim and which, from its position, may very possibly have been a relocation of the old Buycochea claim. Notwithstanding the assistance always offered by the officials of the Spanish Inspección General de Minas in the corrections of technical and legal errors, the Santa Lutgarda claim was an unfortunate one and has been the subject of delays and litigation, the fault, it seems, entirely of the claimants. I quote the following from the report of the Chief of the Mining Bureau to the Acting Civil Governor, *in re* the case of the iron mines of Angat:

"The application of title to the 'Santa Lutgarda' dragged its weary length along from 1873 to 1887 in contest with the 'Ong-Sayco' and with a wanton disregard of the procedure prescribed by law and, as near as this Bureau can tell, the title thereto *was never isued at all,* although the Spanish authorities apparently recognized it as a valid concession, as appears by the official visits of 1887 and 1893, and the statistical reports of 1886 (1884) referred to in the 'Hison' case. One thing is certain that the 'Santa Lutgarda' does not contain more than one claim, and it is even more certain that it never did contain the land embraced in the 'Hison' grant, or any portion of it; and thus the permission given by Süarez, as the heir of the deceased Anchuelo, is presumptuous to say the least, even if it can not de designated by a stronger term."

The permission referred to above is that given to the American prospectors, Wilson and others, to occupy certain portions of the Hison claim.

The "Constancia" claim of two pertenencias was regularly solicited by Francisca Talag on February 22, 1879, and was promptly opposed by Don Hilario Fernando on the ground that the land solicited was his. After various legal formalities it was shown that the property solicited by Doña Francisca Talag, and that owned by Don Hilario Fernando by inheritance from Santiago Hison, were separate and distinct, and on March 8, 1880, Don Hilario withdrew from the contest. The act of demarcation was performed on June 23, 1880, and on August 13 of the same year the title of concession was granted to Francisca Talag. The two claims of the "Constancia" lie immediately north of the Hison claim as shown on the map. The present claimant is Don Pedro Otayco, whose deed of purchase of one pertenencia from Doña Francisca Talag bears the date of July 27, 1901. The price paid was the remarkably small sum of 200 pesos.

To the north of the Constancia pertenencias lies the single claim of the Sapang-Munti Mine. This is on the headwaters of the Monta Muro

Creek, whereas the others just mentioned lie in the mountain forming the west side of the Maon. The Sapang-Munti is a new claim and but little is known of it, excepting that it was regularly solicited on November 21, 1892, by Don Francisco Sanchez, and after due course of legal requirements, the demarcation was performed by Señor Abella on April 16, 1893, the entire proceedings terminating without opposition or hindrance whatever. The proprietary title was issued on June 9 of the same year by the Governor-General, the proceedings being legalized by the Director-General of Civil Administration; and it was registered by the Intendencia General de Hacienda on June 19, and in the General Inspección de Minas on August 18, 1893. Thus we have the refreshing exception of a mine passing through the various stages to perfection of title, without contest or opposition, within a year. This mine was recently sold, I was informed during my stay in Bulacan, for the sum of 7,000 pesos, to a new owner whose name I can not recall, who proposed to combine forces with the "Constancia" smelter and work the deposit for a time.

This brings to a close the skeleton history of the iron mines of Angat. The mines of San Miguel de Mayumo will be the subject for a later report.

The iron deposits of Angat lie in general in the crystalline rocks of the western flanks of the cordillera. I have never heard of any deposits on the eastern side of the range. Among the spurs and more important hills forming the buttresses of this cordillera there are two crests running roughly parallel with the main range, the one beginning near Mount Buga and running to the west of the Sapa-Santol, or Santol Creek, and its headwaters, the Sapa-Tuyo, and terminating a short distance to the northwest of the Constancia claim; and another, possibly a detached continuation of the former, beginning south of Mount Tincugan and running north to the Pahiripan Creek. The eastern side of the first range, draining into the Sapa-Santol, and the Sapa-Tuyo, the western side of the second, draining into the Monta Muro and the Pahiripan, and the western side of Mount Camanglao and the eastern side of a range without name, both drained by the Maon Creek, contain the iron deposits at present known. It must be confessed from the start that no *mines* exist in these hills. A mine in the legal sense is an underground working requiring artificial lighting. The light of common day is ample for all purposes at present in the so-called mines of Angat. Nothing more, so far as I have been able to observe, or otherwise learn, has existed in these iron deposits than the mere sinking of shallow pits for distances of from 6 to 30 feet, through the overlying clay and talc to reach the bed, or the "stripping" to equal depth; and it may be added that a large amount of the ore smelted in the past

came from bowlders of hematite and magnetite found in the beds of the mountain streams. Old mine pits and trenches have become filled and overgrown with forest growth; and even the present limited workings, as above described, which are ample for the supply of the small number of diminutive furnaces in blast, are so completely surrounded with dense jungle, and heavy growth, that the study of the outcrop and strike, and therefore any estimate of the extent or continuity of the beds, are quite impossible.

All indications seem to me, after visiting and inspecting these isolated workings, to point to a more or less continuous bed, or a series of them, for the Angat country at least. The country rock is massive and therefore no dip and strike of stratification are possible. The dips and strikes and thicknesses, however unsatisfactorily they may have been observed, are variable; but this would be expected even in highly contorted stratified rock. It may be safely prophesied that when stratified formations are found in this region, as I expect them to be, they will be found lying with as many dips and strikes as the iron beds present to-day. Therefore the various dips and strikes of these iron beds as observed do not in themselves constitute an objection to the theory of more or less continuity.

On the banks of the Monta Muro Creek, at Sapang-Munti, and at about the center of the claim, the bed of magnetite is extremely irregular, as elsewhere, and the strike is roughly from northeast to southwest. The bed is from 3½ to 8 feet thick and lies almost vertical. The gangue is iron pyrites with serpentine, lying in bands through the bed. The country rock here is a crystalline slate apparently of diabasic origin.

The bed of ore on the Constancia claim, occurring on the steep banks of a little creek called Sapang-Tibagan, which empties into the Maon, has a strike of N. 30° E. and dips 55° to S. 60° E. The ore is hematite and magnetite and is singularly free from pyrites. Above the bed lies a variable thickness of clay resulting from the decomposition of the crystalline massives and immediately over the bed and, in the upper portions, mixed with it, is found green foliated talc. The general thickness of the pure ore, so far as exposed, is from 5 to 6 feet, and with the mixtures of talc and clay the entire iron-bearing bed may be estimated at from sixteen to eighteen feet.

At the time of my visits, in March, 1902, there were two pits, one above the other on the hillside, uncovering the ore bed.

Two little mountain brooks flowing down the hillside eastward to the Maon uncover the present and the old workings of the Hison mine. The little streams are roughly parallel and are both difficult of passage. The northern flows over the outcrop of the present Hison workings, where there now stands a cabin erected by the American prospectors mentioned above. This stream is called the Tusig and its rocky course

is the only thoroughfare to the outcrop; the problem of transportation here, as elsewhere, is more than likely to be a serious one; but in this connection I may suggest that no difficulty seems to stand in the way of aerial wire tramway carriage. The stream bed is strewn with great bowlders of hematite weighing many tons; and this is precisely the reason that so little development has been done upon these deposits; nature has mined the ore, and the smelter men finding sufficient for their limited needs have naturally not delved for more. The strike and dip of the Hison outcrop, I could not even approximately determine, as the sides of the stream bed are precipitous and heavily overgrown, the outcrop here is the only exposure, and little or no development work has been done. The deposit is from 35 to 50 feet thick—in fact the natives say, probably with reason, that the "mountain is iron"—and although the upper layers are impure with pyrites and steatite, the lower 12 to 15 feet are formed of a compact micaceous hematite with apparently no foreign mineral.

The workings of the "Santa Lutgarda" mine consist of two pits sunk for about 12 feet each through the overlying clay, upon the side of Pinugayan Hill. The upper pit, near the top of the hill, is merely the remnant of an ancient working and no observations could be made there. The lower pit, a hundred yards from the Maon, exposes an irregular bed about 10 feet thick lying nearly vertical, with an approximate strike of N. 20° E. The ore bed carries within it streaks of steatite and serpentine, but I saw no pyrites. This has long been considered one of the purest iron ores of the Philippines. The ore is magnetite and hematite, both compact and massive.

The remaining workings of this Angat district have long since been abandoned, and visits to some of them merely revealed crop falls where the soil and alluvium had fallen in and the beds were completely covered. However much satisfaction I might have derived from uncovering the beds in these old pits and elsewhere, I was unable to perform any work of this sort for lack of time.

The information above presented is very meager and is entirely unsatisfactory to me as data upon which to base an estimate of the extent and value of these deposits. Therefore no such estimate will be attempted. I had hoped to find some development work done, particularly upon the old mines, but, as suggested before, the vast quantity of loose bowlders of smelting ore lying in Moan Creek and in most of its tributaries has rendered unnecessary any more arduous or expensive labor than the breaking of these bowlders and the transportation of them to the near-by furnaces.

As to the extent of these beds, I am strongly inclined, from all obtainable data and from inference of the vast amount of float and the broad area represented by the outcroppings and exposures, to think it consid-

erable indeed. As for the purity of some of them I respectfully call attention to the table of analyses and the discussion following. As for the value of them, it must be remembered that many factors must be taken into account, such as the market for ore or pig iron, the cost and difficulty of mining and of transportation, the purity and extent of the ores, and the cost and methods of smelting. With present means of transportation, with the beds of ore neither prospected nor developed, with the market for iron and the cost of importing and erecting mining and smelting machinery as yet uncertain, it is my opinion that the question of the value of these mines to capital is sufficiently important to justify an array and amount of data for its computation, that is not obtainable at the present time. It is well known among mining men that *no* estimate of the value of a mine can be hazarded upon the evidences at the outcrop alone, however favorable. "The value of a mine is the net profit that it will bring to its owner." At this time, therefore, I merely venture the opinion that these beds, being probably very extensive and carrying much ore that is pure, are worthy the development that is absolutely essential for the computation of their final worth.

The accompanying table shows the results of analyses of iron ores of the Angat district, made for me by Mr. Paul Stangl, of the Bureau of Government Laboratories. Reducing the iron determinations to metallic iron by the use of appropriate factors from Fresenius, and adding the respective products, we find:

Total metallic iron.

	Per cent.
No. 1	63.31
No. 3	51.85
No. 4	59.24
No. 5 A	44.16
No. 5 B	60.95

In the above table I have included the iron represented as di-sulphide. Omitting this amount of iron, and retaining that from the oxides only, we find:

Metallic iron.

	Per cent.
No. 1	63.31
No. 3	50.10
No. 4	59.24
No. 5 A	37.33
No. 5 B	60.95

It will be observed that No. 1, No. 4, and No. 5 B are ores singularly rich and pure. No. 1 and No. 5 B are practically free from sulphur and phosphorus, those two most objectionable elements, and all three would suggest themselves as suitable for manufacture into high grade steel by the Bessemer process. The chief impurities are silica and alumina, but these can in no way impair the quality of steel made from

them. Extensive tables will be prepared at some future date showing how well these three ores compare with those of other parts of the world. For the present I respectfully refer the reader to tabulated analyses published in the engineering journals, in the text-books on the metallurgy of iron and steel, and in the valuable publications of the United States Geological Survey and those of the Surveys of the mining States. In passing, I call attention to the remarkable absence of manganese from all of these Angat ores, and to the presence of cobalt in No. 3.

The above ores as sampled by me were *not* picked specimens. In the table following, in which are given the results of a series of assays made in the laboratory of this Bureau in the days of the Spanish Inspección de Minas, it will be noticed that the metallic iron runs higher than in the analyses by Mr. Stangl. This was probably because the ores were sampled from the piles ready for the smelter rather than from the face of the exposure; but of the facts in the case I have no information. Unfortunately the results in metallic iron only are given.

The metallurgy of iron, as at present practiced in these Islands, is confined entirely to Bulacan. At the time of my visit to the iron mines of Angat but one furnace was in blast; and in describing the operation of this I shall describe the operations of all, for I could learn of no variation elsewhere in the province from the practice at the Suarez camarin. It gives me great pleasure to acknowledge here the many courtesies extended to me by Señor Mariano Suarez during my visits to his works. He fully answered all of my many questions and he assisted me in every manner in my measurements, and in the making of sketches and photographs. My facilities for the observation of a furnace in blast were made as complete by him as it was possible for them to be.

The buildings in which the smelting is done are constructed entirely of the products of the forests of the neighborhood. The posts and rafters are of trimmed trunks of trees, the pieces are secured in place by *bejuca,* or rattan, and the thatching is of *cogon* or of nipa—thus no metal of any kind is required, and the camarines are made with the bolo as the only tool. These primitive, but well ventilated, inexpensive, and apparently satisfactory structures are illustrated in sketches and photographs accompanying this report. The Constancia camarin was in process of construction during my survey, and it is here shown with the roof partly thatched. The custom in the hills is for the *maestro,* or smelter foreman, to assemble his assistants, and with them to clear and level the land selected for the smelter site, to dig the clay from the stream banks, bake it into bricks and from these to construct the furnaces, to cut the required pieces and erect and roof the camarin, to prepare the moulds, tuyeres, slag-pots, and blowers, to burn the charcoal and sort the ore, to keep the books and to pay the men, and finally to smelt the iron and send forth the finished product. From the uncleared

forest to the column of *cargadores* bearing the plowshares and points to the market, the entire work is entrusted to the *maestro* and to his assistants. This small industry is a singularly independent one, and so far as I could learn the one requirement of the entire process beyond all that the forests, ore banks, and streams of these narrow mountain valleys could furnish, is a limited amount of boneblack used in coating the molds.

The camarin once constructed is divided roughly into three parts, as shown in the sketch. One side is given up to stalls, or little rooms, in which live the workmen and where are stored the supplies and the furnace products. Another side is divided into ore bins and charcoal bins. The main central space is open and is given over to the smelting proper. In the center of this space are the two furnaces, with bamboo platforms at the sides upon which the feeders stand, with the tapping holes and slag runways at the front, and with the blower or air compressor and the connecting clay tuyeres behind. Opposite the furnaces runs a row of molds, always placed in position for pouring immediately after the last castings have been dumped.

The furnaces are generally made of sun-baked fire clay, the material being obtained from the decomposition of the crystalline feldspathic rocks of the neighboring hillsides. In some cases the bricks are molded, and the furnace is built up of these. In others the furnace itself is molded as one piece, dried, and afterwards bound with rattan or iron. The thickness is so great that, notwithstanding the intense smelting heat on the hearth, the rattan, or *bejuca,* is not burned off. In building the furnace a rectangular space 6 by 8 inches is left above the blow and tap holes, and into these are inserted blocks of a very silicious rock, measuring 6 by 8 by 15 inches, and called *buga* by the natives. The word *buga* is surely a misnomer, as it is the Tagalo for pumice. This quartzose rock is quarried near La Mesa for this especial purpose, and the ironmasters pay 2 pesos for each. They are used end about, and I imagine are for the sole purpose of furnishing silica to the slag. That they do furnish silica is shown by the ends of the blocks when removed.

The hearth of the furnace is shallow and nearly circular. It is from 4 to 6 inches deep and about 2 feet 4 inches in diameter. The total height of the furnace is 7 feet 5 inches, measured from the ground, and the distance from bottom of hearth to top of furnace is 6 feet. The thickness of the annular ring formed by average right section is one foot, although this thickness is slightly greater toward the hearth.

The tuyere is a pipe of best selected and baked fire clay, connected with the blower at one end, passing through the furnace and opening upon the hearth at the other. It is 2 feet 7 inches long, 6 inches in gross diameter, and with an inner diameter of 1½ inches.

The air compressor, or blower, is as ingenious as it is interesting. It

is made from the hollowed cylindrical trunk of a *tanguile* tree and is 9 feet 8 inches long and 1 foot 7 inches in its greatest diameter. One end of this blower rests upon the ground and the other is supported 1 foot 6 inches from the ground by a cross piece of wood. The ends of the blower are furnished with semi-circular valves of leather and wood, suspended from above and closing by the pressure of air against them when the piston moves toward them. The valves are 3½ inches by 7 inches. A separate piece of wood, containing the compartment into which the air is forced and from which it is driven through the tuyere into the furnace, is fitted into the main blower, and made air-tight. It contains an opening at each end into the compressor. The connection between the tuyere and the air compartment is frequently a short piece of cast-iron pipe fitted tight. The piston is a circular piece of wood well fitted and carrying around its perimeter a double thickness of feathers. The piston rod is of *balite* wood, 15 feet long and furnished with a double handle.

The molds for the present smelter practice are of two shapes, and of different sizes for the large, medium, and small castings. These molds are made of carefully selected and ground clay and the bottom halves are "formed" by means of pieces of *narra* wood cut to the shapes and sizes of the castings desired. (Analyses of the clays dug from the stream sides and used in the construction of furnaces, tuyeres, molds, etc., are given in Plate XIV.) The inner surfaces are freshly coated for each casting with a paint made of a mixture of boneblack, ground *palay*, and water. The halves of the molds are placed in wooden frames, bound close together with rattan, and set upon a pair of forked sticks for the pouring. They are well illustrated in the accompanying photographs.

The ore baskets used in feeding the furnace are wedge-shaped and are 1 foot 4 inches long, 1 foot 2 inches wide, and 6 inches at the back. The flat baskets used in feeding the charcoal are circular and 2 feet in diameter and 5½ inches high.

The pouring pot, or ladle, is made of fire clay, bound with iron and furnished with a stout wooden handle. Its inner dimensions are about 8 inches and 6 inches for the larger and smaller diameters, respectively, and 6 inches deep. The few tools, such as pokers, stirring rods for the furnace, and ore hammers and picks for the ore beds, are of wrought iron.

The ore beds are worked, as I have already mentioned, in the open and in the most primitive manner. No system whatever is followed, save the very rudest methods of "stripping" and quarrying. The ore being broken down by means of crowbars, picks, and small sledge hammers, is carefully hand sorted and carried by cargadores to the smelter. Here it is reduced to a uniform size of about 1½ by 1½ by 1½ inches by means of a small cube-shaped hammer having four breaking edges.

The charcoal is burned near by by the smelter men, who cut the forest trees of the third, fourth, and fifth groups for the purpose. They make an excellent quality of well burned charcoal, and to this valuable fuel much of the success of the native smelters is due.

Before "blowing in" a furnace the hearth and body are filled with glowing fuel, the air driven through, and the furnace well and evenly dried and heated. This being accomplished, the ore and fuel are introduced alternately, the proportion for the preliminary stage being one-half an ore-basket, as above described, of metal, to four full charcoal baskets of fuel. After the furnace is well heated, the iron reduced and running upon the hearth, and the blast well on, the normal proportion is thereafter fed to the furnace of one full basket of ore to four of charcoal, and the furnace is kept filled, with a cone of heaped charcoal on top. (In one of the small photographs accompanying this report I have attempted to show the native *maestro* with his one empty ore basket and the four charcoal baskets.) The air compressor is worked at an average rate of 17 strokes per minute, and the pressure and volume seem ample for the purpose. The process of reduction is comparatively simple as the ore is self-fluxing and the fuel is very pure, there being no fluxes required whatever, save that from the *buga* rock above mentioned. This reduction is caused by the carbon monoxide which is itself produced by the carbon di-oxide of the burning fuel coming into contact with the hot charcoal. The analyses of the slag that I sampled are given in Plate XIII, and it will be noticed that the simplicity of the process is paid for with a loss of 20 per cent of metal.

The slagging of the silica and alumina with a certain proportion of the iron is rapidly formed and *escoradores* draw off the slag every two or three minutes when the furnace is working well. The pourings are made every two or three hours. The pouring pot is filled, and the *maestro* passes down the line of molds, with the pot of molten metal upon which floats a cover of burning charcoal; and he rapidly fills mold after mold. The remaining metal is returned to the hearth. As rapidly as the castings harden in the molds the latter are taken down and opened, the castings thrown out, and the surfaces of the molds are relined with paint and prepared for another pouring. About 15 molds are in constant use by one furnace in good running order, 8 of these for plowshares and 7 for points.

The finished product, as made at present in the smelters, is of the largest size only of plowshares and points. These are exhibited in various positions in photographs accompanying this report; and I have attempted a sketch in which are shown the use of the parts on the Filipino plow. The plowshare of this largest size weighs 4 9-10 pounds. The castings are only fairly good in quality and might be greatly improved.

The expenses and profits of this industry are too variable to be readily ascertained. During the plowing months, May and June, the pair, which consists of a plowshare and a point, bring 1 peso, and the Angat people buy the entire product. During the other months a large part of the product is sent to Manila and is sold here at the rate of from 70 to 90 pesos per hundred pairs. The costs of transportation are variable. Señor Suarez pays the cargadores one real for each pair carried from the smelter to Angat, and as each averages about eight pairs he makes 8 reals or 1 peso for the round trip of about 15 miles. When the roads are good it costs 4½ pesos to get 100 pairs to Manila; when they are bad, as in the rainy season, it costs 7 pesos. Because of the shortage of labor, at the wages Señor Suarez can afford to pay, he informed me that he can not get enough men to keep even one furnace in blast. He said that he would work three furnaces if he could get the men. During my visit he complained that we Americans overpaid native labor throughout the Islands and that native employers with limited plants could not compete for labor. As it is he must blow out his furnace from time to time to put his limited force to cutting timber for charcoal, to the making of molds, tuyeres, and other supplies, and to general repair work. He estimated four months' smelting a year as good, that is, producing from 2,000 to 3,000 pairs each month, four months, as medium, or producing from 1,500 to 2,000 pairs, and four months, during which time the furnace is largely out of blast, as poor, or producing from 800 to 1,000 pairs.

The laborers required for one furnace are almost as many as for two and are 2 *maestros* or foremen, who have general charge, 1 *escribiente*, or clerk, 2 *escoradores*, or slagmen, who also act as *brajenantes*, or molders, 4 *heladores*, or blowers, and from 4 to 7 other common laborers who obtain and prepare the ore and fuel. These men are "found" and are paid by the amount produced, the unit being 60 carabao loads of 20 pairs each. Señor Suarez told me that the food he gave the men depended upon the quantity and quality of their work, and that when everything was running well and the output steady and large he fed them with the best he could buy. He estimated that the cost to him in food and wages, for men enough for one furnace, averaged about 60 pesos a month during the working season, or about 40 pesos through the year, and that the variation was between 20 and 100 pesos. His annual taxes during the Spanish régime were 115 pesos to the General Government and 48 pesos to the pueblo of Angat. He seemed much concerned over the cost that his fuel would be to him under the present Forestry Regulations. He stated that he cut only the cheaper grades of trees for charcoal, and yet, upon looking over the taxes imposed at the present scale, he said that he would be compelled to shut down if he were forced to pay the full amount. I could get no statistics whatever upon this subject of the cost of his fuel, and this is a matter of regret to me

because it is a most essential factor in the operation of furnaces in this region upon a larger scale.

With the above incomplete data I have attempted to form some sort of estimate of the profits of one furnace, run under unfavorable conditions. With more furnaces and improved methods the profits would correspondingly increase. One great difficulty in the attempt at an estimate is the division of product as to place of sale, the profits being greater when the plowshares are sold in Angat. The following is intended to be more suggestive than accurate:

Estimate of profits from one blast furnace.

	Mexican currency.
Sale of 6,000 pairs in Angat at $0.90	$5, 400. 00
Sale of 14,000 pairs in Manila at $0.75	10, 500. 00
Annual receipts	15, 900. 00
Transportation of 6, 000 pairs to Angat at $0.12½	750. 00
Transportation of 14,000 pairs to Manila at $0.70	9, 800. 00
Wages and food for employees for 20,000 pairs	1, 000. 00
Taxes under Spanish régime	163. 00
Annual expenditures	11, 713. 00
Annual profits	4, 187. 00

In the above no account has been taken of cost of mine and plant. The latter, of course, costs very little indeed. There is, and has been, so much unfortunate litigation and quarreling over these mines and camarines that no data on the subjects were obtainable.

It would seem that if a market could be assured for a large output of these plowshares and other castings, or of pig iron of high grade, if charcoal can be had at reasonable rates or if our Islands can furnish lignite of a quality to give good producer gas, if the transportation rates can be materially reduced, and if competent labor can be secured—that a large modern furnace smelting the best of these ores could operate at a handsome profit to its owners. I am inclined to think that the above conditions *can* be satisfactorily settled and that there *is* a future for the iron industry in the Philippines.

Herewith I give the only statistics available of iron production in Bulacan. The information is for the year 1884 and was furnished by the governor of Bulacan on February 4, 1886.

Statistics of iron production in Bulacan, 1884.

Pueblos.	Number of furnaces.	Number of plowshares.	Number of operatives.
San Miguel	3	20, 000	25
San Miguel	2	10, 000	10
Angat	2	12, 000	18
Angat	1	8, 200	14
Angat	1	8, 200	14
Total	9	58, 400	81

Of the remaining factors in the mineral industry of Bulacan, unfortunately but little could be learned. This province has undoubtedly produced some placer gold in past years, but no statistics whatever are available. Some months ago a prospector showed me several ounces of rather coarse placer gold that he said came from the hills of Bulacan; but he offered no information whatever as to the location. This reticence at that time was of course most natural; there was then absolutely no legal protection whatever for these men in their finds. Several prospectors whom I met in Bulacan told me that they had washed the sands of many of the streams but had found nothing excepting in the hills to the north of Norzagaray where there was some placer gold. My guides frequently spoke of gold in the streams, but their descriptions were too vague to be of any worth. José Fajardo told me that a small *sapa,* or stream, emptying into the Angat just above the town of that name carried gold, and that he had staked out several claims. He also said that the Sapa Apo, which was very indefinitely described, at one time carried a great deal of gold. And so there are rumors, and tales that are told; but of definite information there is nothing. The purposes of my survey were either unintentionally, or willfully, misunderstood by some of the American prospectors; and I therefore made it a point to confine myself to information that I could readily obtain without misunderstanding of any kind, knowing that professional prospectors are the best seekers after gold, and that their discoveries under the protection of mining laws, would soon furnish the information desired. I fully expect to hear of discoveries of both placer and quartz claims in the upper hills of Bulacan.

Graphite pebbles were found by me in the bed of the Pangisijan Creek near Mount Tucod. No further evidences of a deposit was obtained, although I examined the headwaters rather carefully for them. Among the metamorphic rocks of the cordillera there probably exists deposits of this valuable mineral.

Lignite of a very inferior grade and in thin seams has been formed in the shales of Bulacan. I saw two of these seams, one at the barrio Sampaloc, in the shales exposed by the Bayabas, and one on the upper Sapa-Santol. They were absolutely valueless, neither being more than a few inches thick. An inferior lignite is also found in the arroyo Laguio Malaqui near Norzagaray. No coal mining has ever been done in this province, and no concessions for coal have ever been granted here. The importance of a good lignite in Bulacan capable of furnishing producer gas for future iron smelting can not be overestimated. In Rizal Province, under conditions similar somewhat to those in Bulacan, an excellent gas-making coal has been discovered in quantity. It is possible that such deposits may yet be found under the coral limestone formations of Bulacan. It is notable, in this connection, that no valu-

able coal has yet been discovered in the mountains east of the plain of central Luzon, with the single exception of reported finds near Baler, on the Pacific coast.

Building stone of good grade and great beauty can be quarried from the crystalline rocks of the range. The tonalites, or the fine-grained quartz-diorites, and the aplite, would make handsome stones capable of receiving high polish. The development of this industry, however, must indefinitely await a demand for the stone and for better transportation facilities.

Vast quantities of limestone are available in Bulacan for use as road metal, as furnace flux, as building stone, and for the working of lime. The latter is the only purpose for which limestone is now used, and this branch of the mineral industry is practiced, as far as I could learn, at Banabang only, on the Bayabas River, near Angat. The range of hills, of which Mount Pecote is a prominent part, showing extensive exposures of a fine-grained cream-colored limestone on their western slopes. This rock is not regularly quarried, but the large slabs and bowlders of the rock lying on the surface of the ground are broken, and carried to the kiln at Banabang, a half mile to the west. This limekiln is fired up only when there is a sufficient demand in Angat, or in some of the other towns, for several hundred pounds of lime. It is owned and operated, I was informed, by five natives, residents of Angat. These partners in the business do all the work of obtaining and hauling the stone and fuel, and of digging and puddling the clay required for building up the sides. There is therefore no expense for labor, and, as they pay nothing for either stone or clay, the expense account is practically that of the fuel. The native operators use dried bamboo stalks for fuel, and they say that by burning these they can obtain a hotter fire than with wood or charcoal. The stalks are cut in lengths of 4 feet and are piled like cord wood near the kiln. The unit of measurement and of payment is the "talacsan," which is 1 vara long, 1 vara high, and 4 feet wide. The requirement for one firing is 60 "talacsans" which cost 1 peso each. The average product of lime in one firing is 300 cavans, or about 640 bushels. The lime is of excellent grade and now sells in the towns for a peso a cavan, whereas in the days of the Spanish régime it brought but a peseta a cavan. Therefore for one firing, producing 300 cavans worth a peso each, the total cost of which amount is 60 pesos, the profit is evidently $300-60=240$ pesos. This divided among five men yields 48 pesos each for 15 days of work. There is apparently a comfortable profit to the owners in this small business. The lime made by them is fine and white, and has a very good reputation in the towns and is in fair demand. It has not been used in agriculture so far as I could learn.

The process is of course a very simple one. The limestone or calcium carbonate being properly heated in a partially closed oven gives up its

carbon-dioxide and remains as calcium-oxide. A sketch is shown herewith exhibiting the principal dimensions of the kiln. The body of the oven is below the surface of the ground, as is the firing box. The hole from which the lime is taken opens upon the bank of the stream just above the road, so that loading upon carts is readily facilitated. The red clay dug from the fields is puddled by foot. The slabs of stone are piled in the form of a hive with a hollow space within and with an opening into the firebox. When the arrangement is complete the outer surface is covered with straw for 3 or 4 inches and over this is carefully plastered the clay to the same thickness, with a series of holes through the shell for draft. The draw hole is then tamped with clay, the kiln is gradually heated, and finally the proper degree of heat is obtained and continued to the end of the operation. The draw hole is opened from time to time for the removal of the ashes. The firing requires eight days and nights of continuous attention, and the preparation for each burning requires seven days of labor. There were formerly two kilns in operation at Banabang, but at the time of my visit there was but one.

CONCLUSION.

Before concluding this report I wish to repeat my appreciation of the work of Mr. Martin, the photographer of the Bureau of Government Laboratories, whose photographs accompany this report. Mr. Martin's work speaks for itself, and it is a pleasure to record the fact that with him exist the combination of exceptional ability and devotion to the good of the public service.

Should the Government ever take steps toward the setting aside of certain public lands as parks, in order to preserve whatever unusual natural beauty may be found therein, I beg to call attention to the Puning Çave and that part of the valley of the Puning Creek immediately adjacent.

In summing up the geology of Bulacan I refer again to the fact that the crystalline massive rocks have been found in place in the cordillera, which fact confirms the hypothesis of Itier and von Drasche, and which settles a point apparently in doubt during the compilation of the "Geology of the Philippine Islands," by Prof. G. F. Becker, of the United States Geological Survey. I further call attention to the finding of a vegetable fossil, encased in a pebble in the stream bed of the Bayabas, which, I believe, is the oldest fossil in point of geological history yet discovered in the Philippines. It apparently points back to the early Mesozoic, possibly to the Paleozoic!

The mineral resources of the province have been as fully discussed as time and the data obtainable would permit. The interesting method of smelting the iron, which is over a century old, and the origin of which I have not ascertained, is fairly well illustrated by sketches and photographs.

For ready reference I have given lists of illustrations and photographs, and a skeleton index of the report.

In conclusion, I beg to express the hope that this preliminary field work may but be the first of many surveys and studies to be prosecuted by this Bureau; that the future work may be broadened, and its usefulness increased, by an added force to the personnel so that with a division of labor a much greater amount of work can be performed; and that, finally, the earnest efforts to make the results of this first survey of value, may have so far been successful, that encouragement may result for extensive work in the future in the study and development of the mineral resources of the Philippine Islands. Capitalists are always willing to pay, and to pay well, for mines, quarries, or other mineral deposits that they know to be of worth; the discovery and development of these, fair and honest reports upon them, and inducements to capital to invest in them, will result in largely increased business in these Islands, in better transportation, in better wages, in a natural pride on the part of the natives in the value of the metallic wealth hidden in their hills, and finally in such an increase in industrial prosperity as could never have been known had not the capital and brains of the outside world been invoked to that happy end.

Respectfully submitted.

HIRAM DRYER MCCASKEY, B. S.,
Mining Engineer for the Mining Bureau.

PLATE A.—CAMPS OF THE SURVEY.

PLATE B.—TRANSPORTATION OF THE SUPPLIES.

PLATE C.—NATIVE MAESTRO, WITH ORE AND FUEL BASKETS. FURNACE IN BLAST.

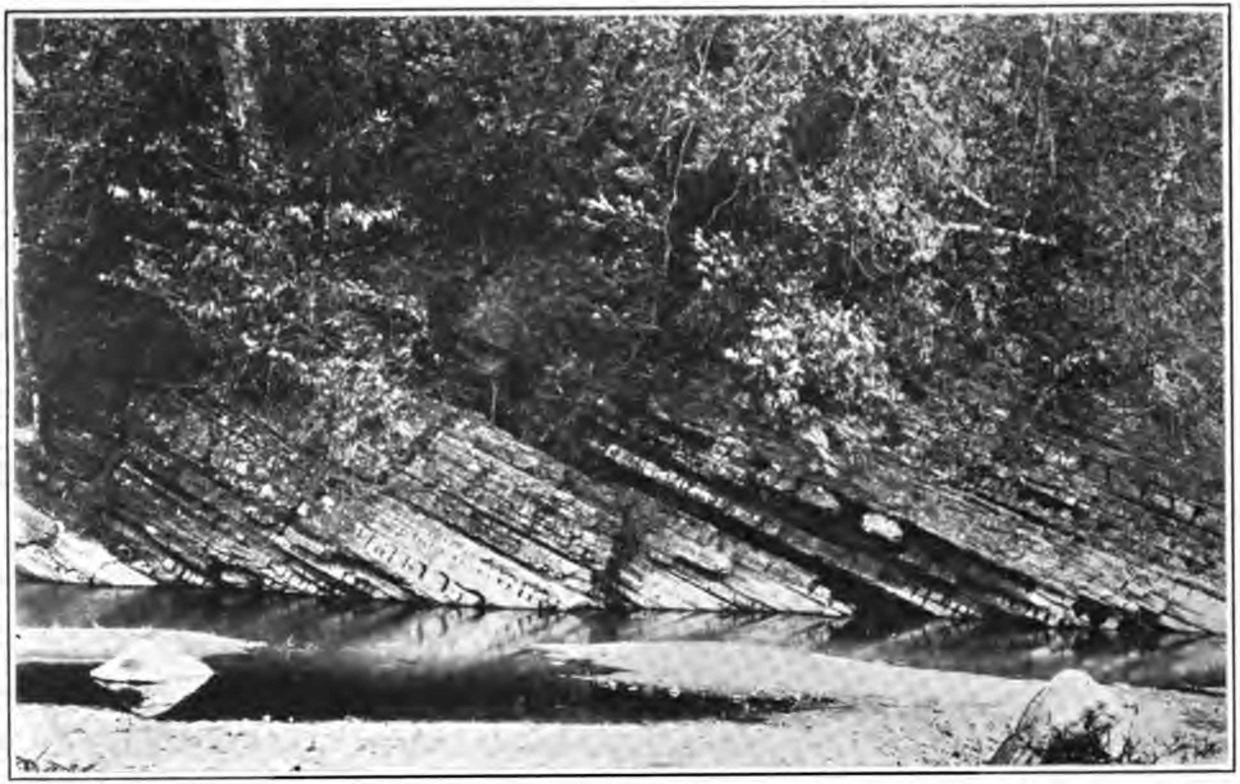


PLATE D.—LIMESTONE BEDS. BAYABAS RIVER ABOVE SANTA MARGARITA SPRING.

PLATE E.—LIMESTONE BEDS. BAYABAS RIVER ABOVE SANTA MARGARITA SPRING. NEARER VIEW.

Plate F.—The "Trail" up a Branch of the Maon Creek to Hison Mine.

Plate H.—THE BED OF ORE AT THE OTAYCO (CONSTANCIA) MINE.

Plate I.—CAMP BURRITT.

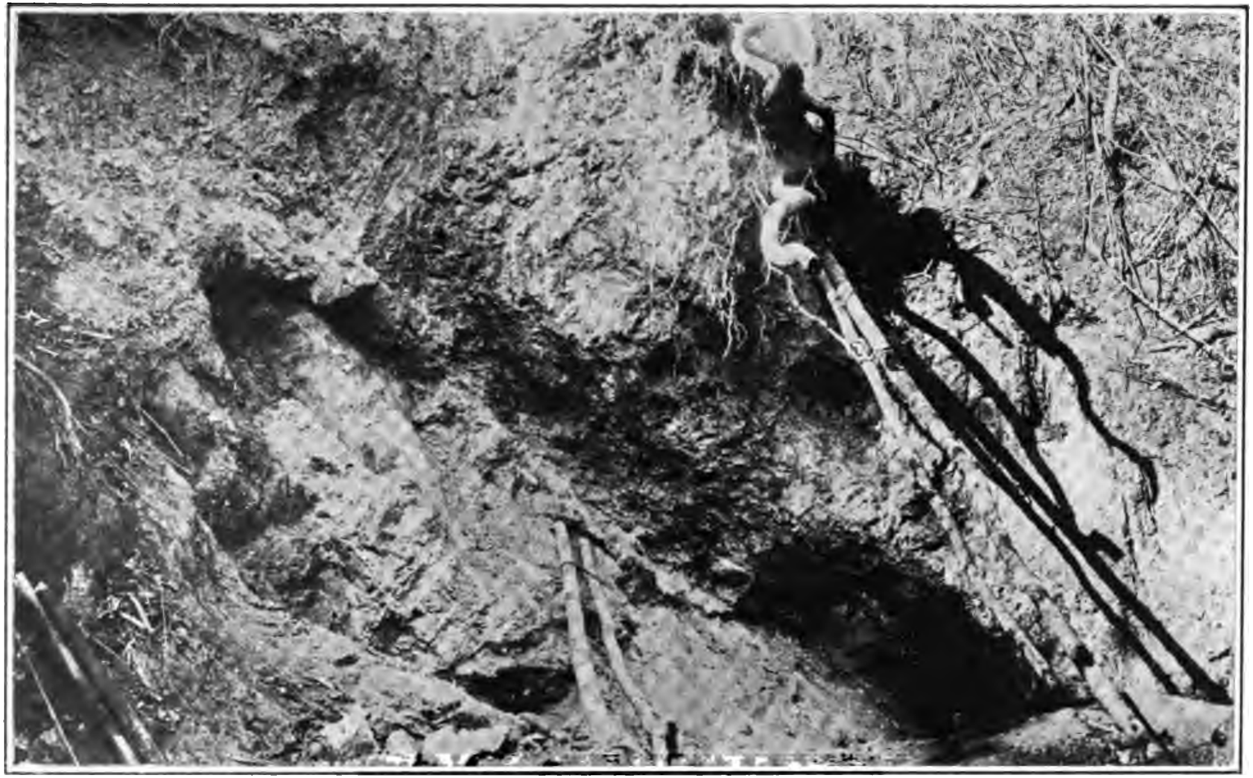


PLATE J.—NEARER VIEW OF ORE BED OF CONSTANCIA MINE.

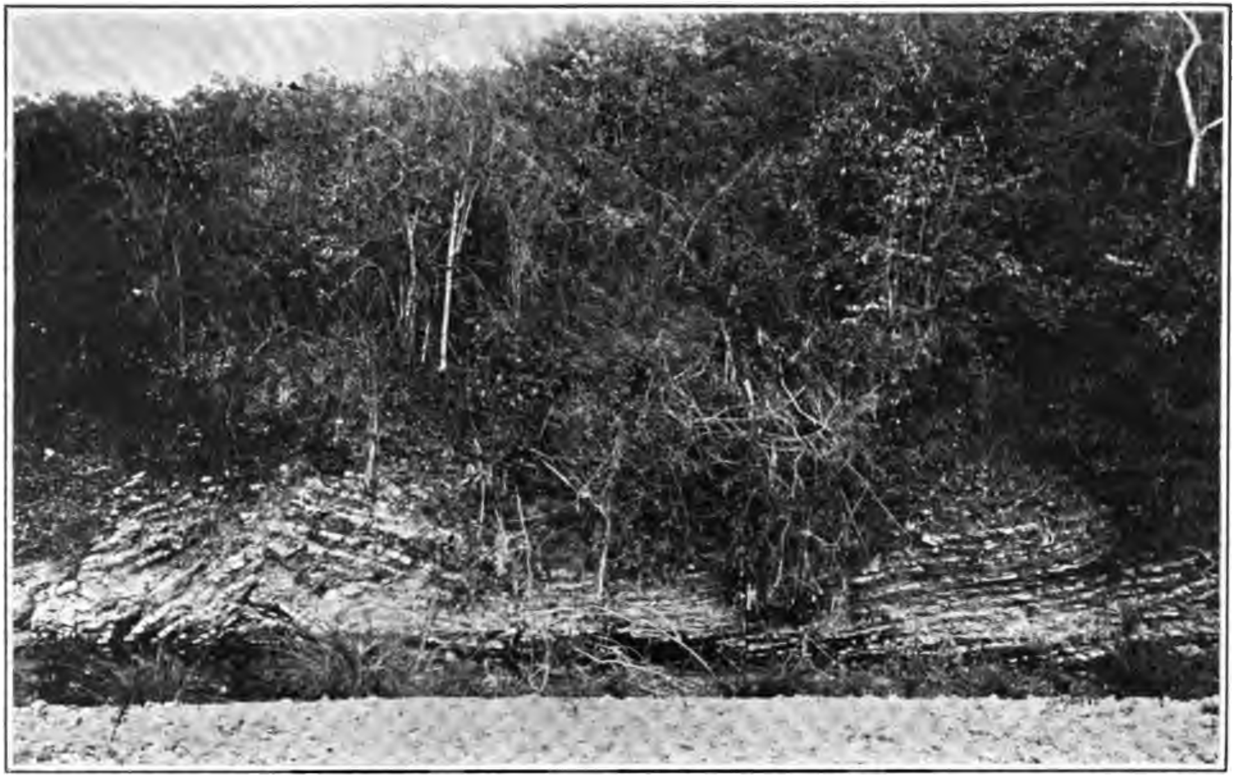


Plate K.—FOLDED LIMESTONES AND SHALES. BAYABAS RIVER, LA MESA.

PLATE L.—ORE BEDS OF OLD HISON MINE.

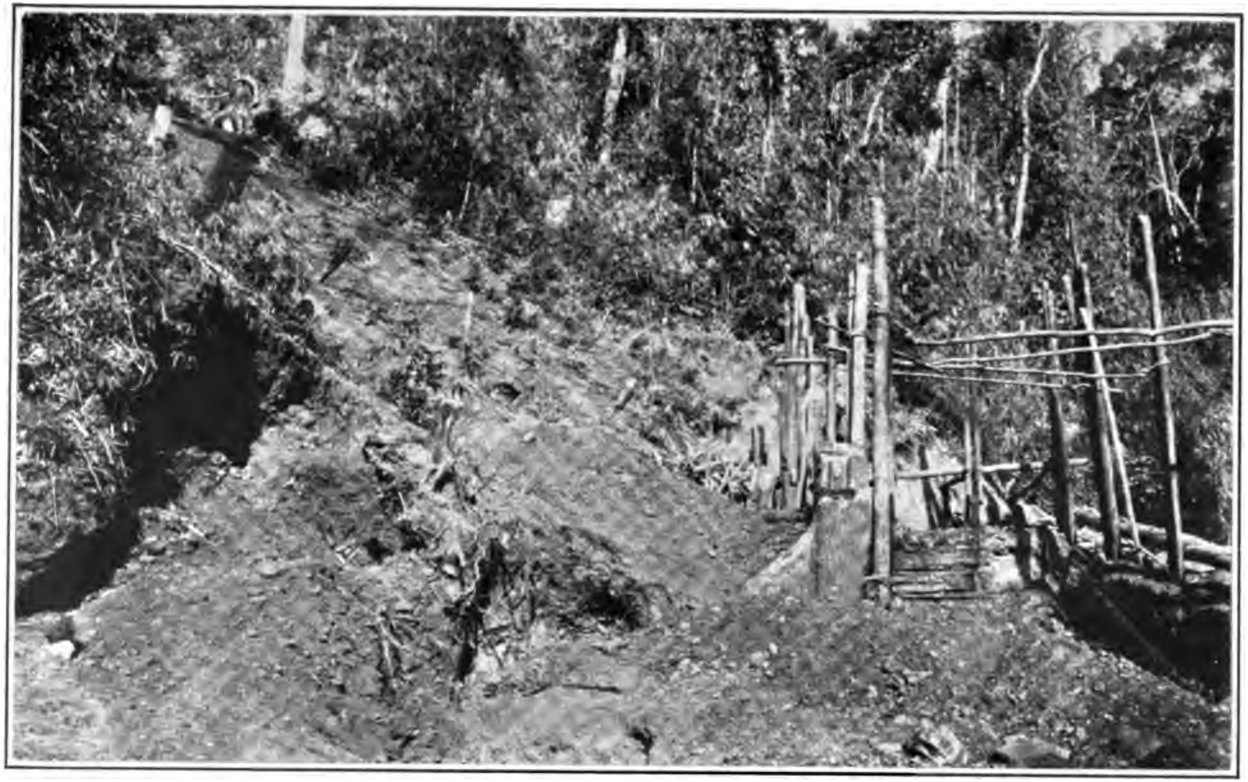


Plate M.—PREPARATION FOR CHARCOAL BURNING. SUAREZ CAMARIN.

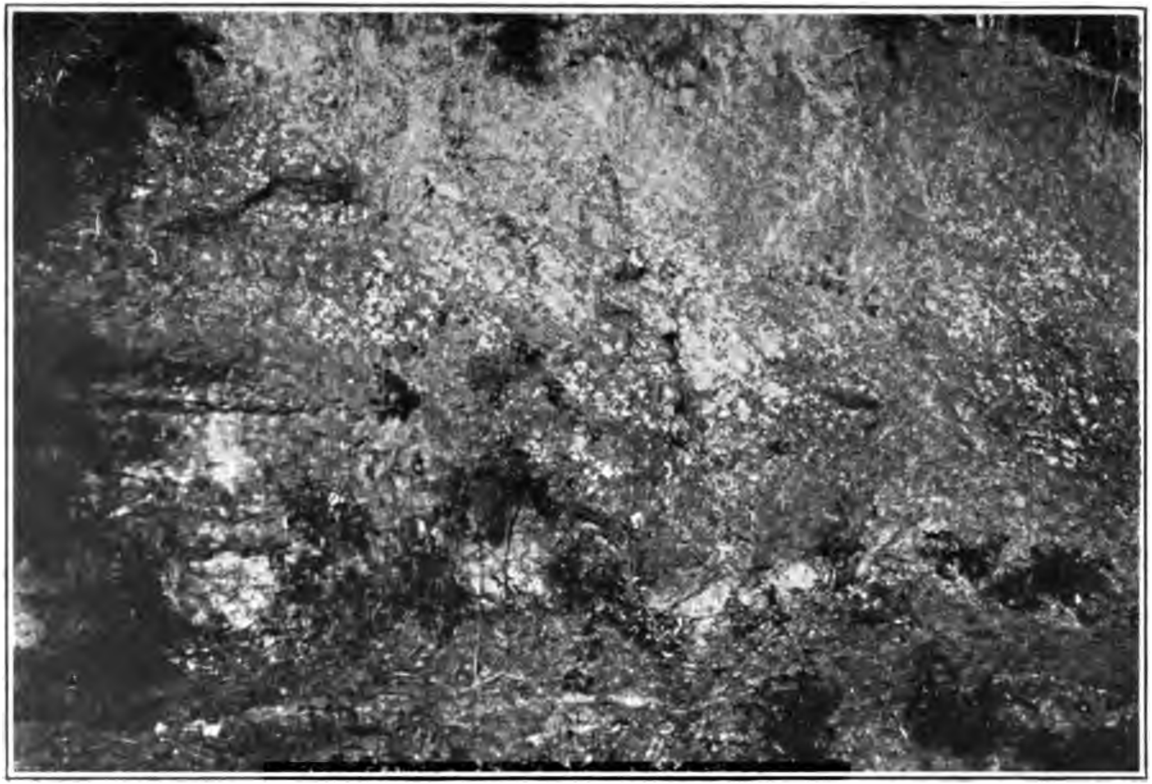


Plate N.—FACE OF STRIPPING TO UNCOVER ORE BED. HISON MINE.

PLATE O.—ORE BED. CONSTANCIA MINE.

PLATE P.—HILLS AND PLAIN. FROM MOUNT CALABAZA TOWARD MANILA.

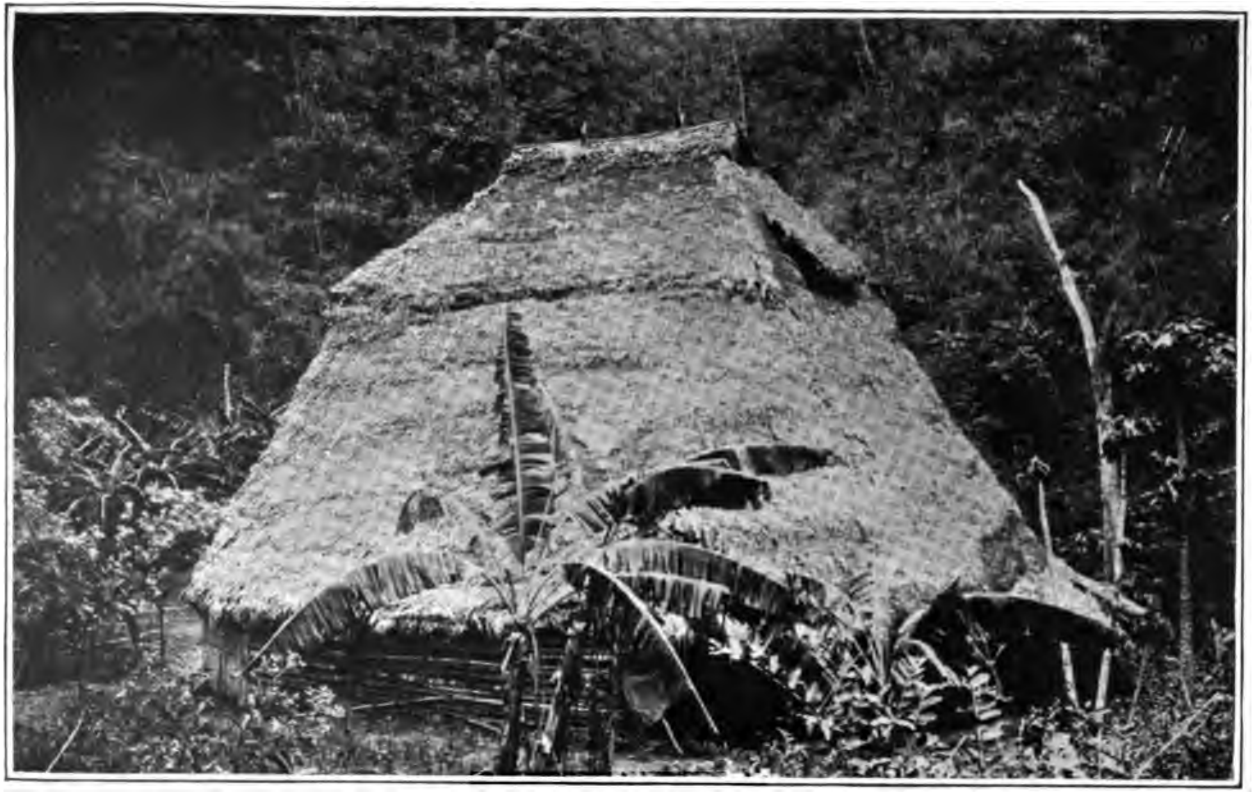


Plate Q.—THE OTAYCO CAMARIN.

PLATE R.—INTERIOR OF SUAREZ CAMARIN SHOWING TUYERES AND MOLDS.

Plate 8.—INTERIOR OF SANTIAGO CAMARIN. PISTON, TUYERES, AND BLOWER.

PLATE T.—INTERIOR OF PUNING CAVE.

Plate U.—PLOW POINT IN CENTER. SHARES OF TWO SIZES.

Plate V.—PLOW POINT IN CENTER. SHARES OF TWO SIZES.

Plate W.—PLOW POINT IN CENTER. SHARES OF TWO SIZES. BACK VIEW.

PLATE X. LOOKING DOWN BAYABAS VALLEY FROM LA MESA BARRIO.

Plate Y.—LA MESA BARRIO.

NING IN THE CENTER. GENERAL VIEW OF

PLATE AA.—PANORAMA FROM MOUNT MAQU

.LO

PLATE AC.—MOUNT TINCUGAN FROM MOUNT CALABAZA.

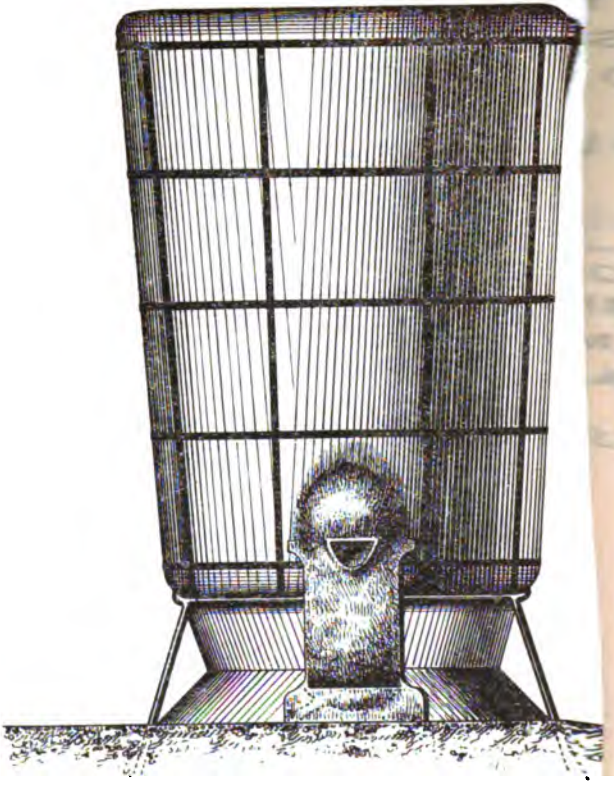
Plate AD.—Mountains and Forests. From Mount Calabaza looking east to Mount Pilong-Pilong.

Plate AF.—LIMESTONE BOWLDERS IN BAYABAS RIVER JUST BELOW CAMP BURRITT.

Plate AG.—LIMESTONE ROCKS IN PART IN PLACE. BAYABAS RIVER.

PLATE AH.—TRAIL ON MOUNT CALABAZA LEADING INTO FOREST.

PLATE AI.—PREPARATIONS FOR CHARCOAL BURNING. SUAREZ CAMARIN.



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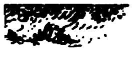
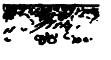
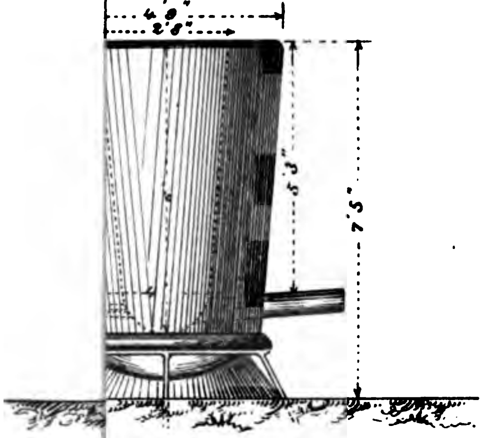
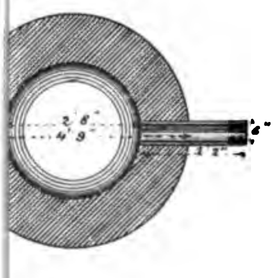






4'9"
2'8"
5'3"
7'5"



2'8"
4'9"
6"

Sketch of Filipino Plow, showing arrangement of share and point

Scale 1: 10

The Mining Bureau
Manila 1902

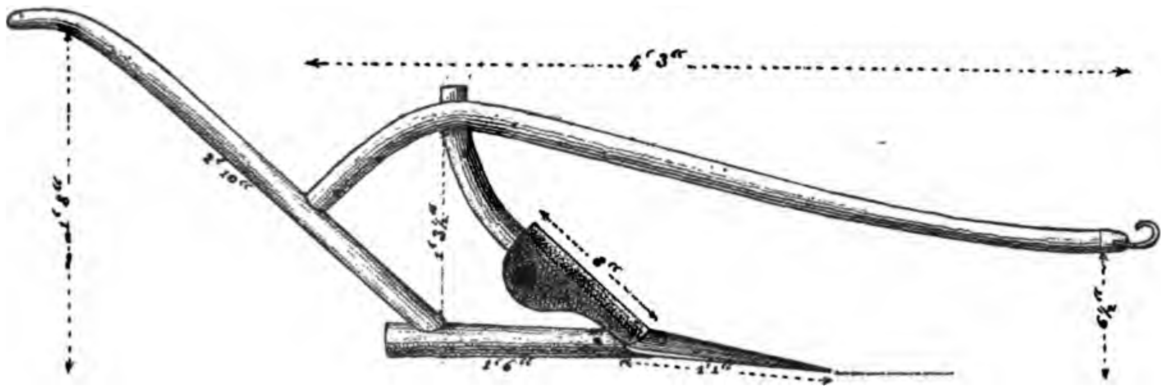


Plate IX.

The

Analyses of Some Iron

Mr. Paul L. Strangl. Analytical

	#1 Hemalite					H	
FeO	0	1	.9	2	2	0	5
Fe_2O_3	8	8	.2	2	5	6	5
MnO	-	-	-	-	-	-	-
CaO	0	0	.1	2	6	0	8
MgO	0	0	.1	8	3	0	1
Al_2O_3	0	6	.5	2	3	1	0
FeS_2	-	-	-	-	-	0	3
CO_2	0	0	.0	1	0	-	-
H_2O	0	0	.0	4	1	0	0
SiO_2	0	2	.2	4	0	0	6
P_2O_5		Trace				0	0
TiO_2	0	0	.7	7	0		
CoO	-	-	-	-	-	0	1
Total	10	0	.0	4	0	9	9

Notes - #1 _ Micaceous Ore from Hizon
#3 _ Compact, brittle. Luster
#4 _ Crystalline - massive. Const
#5A _ Second class ore. Upper
#5B _ First class ore. Lower p

Mining
Ores – Ir
by
Chemist,

	No. 3 Hematite			Mag	
	1	4	3	3	2
	8	6	2	4	8
	-	-	-	-	-
	0	4	0		T
	5	1	3	0	1
	1	0	0	1	5
	7	5	4		T
	-	-	-		T
	3	7	0	0	0
	7	1	9	0	2
	2	4	3	0	0
Trace				0	0
	0	3	9	-	-
	9	8	3	10	0

mine. Soft a
metallic. Fro
ntia mine.
bed, mixed wi
ortion. Consta

PLATE X.

Assación de Minas.

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7 %
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BULLETIN No. 4
Pl. 1-43

DEPARTMENT OF THE INTERIOR

THE MINING BUREAU

MANILA

A PRELIMINARY
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MANCAYAN-SUYOC MINERAL REGION, LEPANTO, P. I.

BY

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GEOLOGIST, MINING BUREAU

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LETTER OF TRANSMITTAL.

THE MINING BUREAU,
Manila, P. I., October 19, 1905.

SIR: I have the honor to transmit herewith, recommending its early publication, the material prepared by Mr. A. J. Eveland, geologist, Mining Bureau, for Bulletin No. 4 of this Bureau, entitled "A Preliminary Reconnoissance of the Mancayan-Suyoc Mineral Region, Lepanto, P. I."

This result of the first field work by Mr. Eveland, in difficult Philippine fields, should be of value to those interested in the mineral resources of these Islands, and, in my opinion, reflects much credit upon Mr. Eveland and the party under his charge.

Very respectfully,

H. D. MCCASKEY,
Chief of the Mining Bureau.

Hon. D. C. WORCESTER,
Secretary of the Interior, Manila.

LETTER OF SUBMITTAL.

THE MINING BUREAU.
Manila, P. I., March 28, 1905.

SIR: I have the honor to submit herewith the manuscript of a preliminary report on the mineral deposits of the Mancayan-Suyoc region of Lepanto Province, Island of Luzon, P. I. It has been prepared for publication as a bulletin of the Mining Bureau.

Very respectfully,

A. J. EVELAND, *Geologist.*

Mr. H. D. MCCASKEY,
Chief of the Mining Bureau, Manila, P. I.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

Maps and Sections.

1. Index map showing route of party and area surveyed (Pl. I).
2. Map of Minas de Cobre, Mancayan (Pl. VIII).
3. Ideal section (Pl. XXIII).
4. Plan of workings of Mancayan mine (Pl. XXXVI).
5. Route map, Candon to Mancayan (Pl. XLII).
6. Topographic map of Mancayan-Suyoc area (Pl. XLIII). — [illegible] 10/23/06

A PRELIMINARY RECONNOISSANCE OF THE MANCAYAN-SUYOC MINERAL REGION, LEPANTO, LUZON, P. I.

By Arthur J. Eveland.

Chapter I.

INTRODUCTORY.

FIELD WORK.

The field work upon which is based the following preliminary report on the mineral deposits of the Province of Lepanto, Luzon, P. I., occupied the latter part of the "winter" season of 1903–4, and from early in March to the middle of June. This period of three and one-half months may by no means be taken as the time available in the investigation of the area, as the early advent of the rainy season rendered work impracticable approximately one-half of that period, the daily torrential rains terminating field work with unfailing regularity. In addition to the time spent actually in the field, six weeks were required for transportation to and from Manila, and at the close of the season's work, discontinued when it was absolutely impossible to do more, one section of the party, with the collections and equipment in its care, occupied six weeks in the return to Manila.

Topographic mapping has as yet not been undertaken in the Philippine Islands. Only to a small extent has any primary triangulation work been carried on, and that only on the coasts and harbors, under the United States Coast and Geodetic Survey. The party was therefore organized as completely as possible under the conditions, for varied and general work, and consisted of the writer as geologist and chief, with Mr. H. M. Ickis and Mr. M. Goodman, field assistants, and two rodmen. The absence of one field assistant was unavoidable for over a month, and the connection of one rodman with the party was severed almost immediately upon reaching the field, so that the party practically consisted of the geologist in charge, with one field assistant, one rodman, and such native (Igorot) labor as could be obtained, for the major part of the time.

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No detailed investigations, except such as could be profitably carried on with the limited force and time at hand, were contemplated. The region which was to be visited has been long prominent in the infant mineral

industry of the Islands, and only such work that would give a better and fuller knowledge of the mineral resources of the region and an aid to those interested in its development and future progress was undertaken.

For these and other reasons this report is not comparable with more extended and detailed studies, which, it is hoped, are to be undertaken in the near future, but attempts to approach more closely such reconnoissance work as was carried on with wonderful success by the United States Geological Survey in Alaska. Indeed, the conditions of Alaskan work are not greatly dissimilar to the conditions under which all scientific field work is accomplished in the Tropics. The lack of transportation facilities is one of the worst evils to deal with. For every item in the equipment and supplies of use during a more or less extended field trip there is a problem large in its proportions. In the present work the absence of horses or any pack animals thrusts the burdens, literally, on the shoulders of mankind. And the Asiatic races, while much may be said in their favor, do not, as a rule, take kindly to continued labor.

In carrying on geological work one meets with the excessive vegetation of the Tropics, limiting one's vision to a matter of feet, and, in correspondence, the great thickness of soil and decomposed rock material render the solution of even the most simple stratigraphic problem a labor in itself. And considerably not the least in proportions are the climatic conditions which Europeans have to face.

In view of these conditions, therefore, the report submitted is to be understood to be purely preliminary in scope, and the results and deductions based upon it may possibly be subject to future revision and modification when more detailed investigations are carried out.

The actual route, which is indicated in the index map (Pl. I), and means of transportation of the party are briefly as follows: From the map it will be seen that the area indicated lies approximately 160 miles almost due north of Manila. The railroad from Manila north at present only reaches Dagupan, in the Province of Pangasinan. As the most direct means of reaching the territory, then, the party, with its outfit, provisions, and other equipment, was embarked February 24 on the Coast Guard steamer *Masbate* and on February 27 was disembarked at Candon, in the Province of Ilocos Sur.

The trail inland, up the valley of the Balidbid River to Salcedo, north along the western flank of the Cordillera del Teila to Concepcion, then over the Teila Pass to Angaqui, and south to Cervantes, in the valley of the Abra River, presented no other difficulty than lack of transportation. Owing to delays in securing "cargadores" it was not until March 6 that Cervantes, the capital of Lepanto-Bontoc Province, was reached; but finally, on March 11, the first permanent camp of the Mining Bureau party was pitched at Mancayan, the "barrio" or village which was the seat of mining operations of considerable importance in the past.

For two months Mancayan was made the base of operations for that

Photo by A. J. Eveland.

LOOKING N

Photo by Martin.

TRANSPORTATION METHODS IN LEPANTO.

Photo by A. J. Eveland.

HACIENDA TUBOC.

portion of the mineral region. At the end of about that time camp was shifted to Suyoc, some distance to the south, from which the operations were completed.

It may be well to give a brief résumé of the work done, in order that the understanding may be fully clear.

Of prime importance to any geological work, the topographic base map merits the first consideration. As the relative position of this area could not be determined from any previous maps or data, recourse was had to astronomical methods, and permanent monuments erected on determined points. Checking on these, a base line was laid out, according to the customary procedure, with its conjunctive system of tertiary triangulation over the area. On account of the numerous claims recorded and the evident disposition of the mining fraternity to develop and operate this district, a rather detailed topographic map of a region about 6 miles long and 4 miles wide, on a scale of 400 feet to an inch, was made. It is believed that this map will be of inestimable value to future development work in this district, and therefore more attention was given to it than the general character of the investigation would seem to call for.

The general investigations were conducted along three distinct lines, viz:

(1) A hasty reconnoissance of a large area considerably beyond the immediate vicinity of the "mineral region."

(2) Route surveys, from the coast to the mineral region, by two distinct routes.

(3) A detailed study, as far as the operations permitted, of the ore deposits and geology of the district proper.

In connection, data were recorded for the future more purely geological work in the Islands, the work instituted under the Spanish régime by Abella, Centeno, Santos, Von. Drasche, and others, and which will be carried on under American direction and operation.

As stated before, the advent of the rainy season terminated further work in June, and the party returned to Manila. The geologist proceeded overland to the south, through the Province of Benguet, for a hasty reconnoissance of the valley of the Agno River, and to examine the mineral districts of Benguet in order to prepare for the field work in the future, when these areas will be taken up. The mountain trails were followed as far as Baguio, the capital of Benguet, and from there on the route was via the new Government road to Dagupan, where connection with the railroad is made. At the time of the arrival of the geologist in Dagupan railway communication was broken, due to heavy floods, and a steamer was taken to Manila. The entire trip south was made under extremely hard conditions, the floods and storms attendant upon the rainy season being the prominent opposing factor.

The remainder of the party, under charge of Mr. Goodman, field assistant, took the back trail via Angaqui, Concepcion, and Salcedo to

Candon. Boats could not make a landing at that season of the year, neither was it possible, owing to the flooded condition of the coastal plain rivers, to proceed northward to a possible favorable embarking point. In fact, the return from Cervantes to Candon was attended with the utmost danger and hardships at all stages of the route, and that, in addition to bringing safely through the equipment and collections, a detailed route survey was made is greatly to the credit of that portion of the party. It was able to make its way south to San Fernando, thence via steamer to Dagupan, and from there, railway communication having been restored, to Manila. From San Fernando, while awaiting transportation to Manila, a survey was made via Baon, Naguilan, and Sablan, to Baguio, the capital of the Province of Benguet, more or less the central point of the mineral district of that province. By the two route surveys described above the two main lines of communication to the coast from the mineral regions have been accurately mapped for the first time. Comment on the future value of these surveys is unnecessary, and they are included in the text.

The foregoing outline gives briefly the actual movements of the party, in their general relations to the Island of Luzon. Of the difficulties that were met with and overcome, nothing can be written that adequately presents the true conditions. Geological work in the Tropics has for its attendant evils, and to a very small extent, benefits, certain conditions that nothing but actual experience reveals.

ACKNOWLEDGMENTS.

In the course of the field work the Mining Bureau party had reason to be grateful for much assistance in various ways. An attempt is here made to acknowledge these aids and to express the keenest appreciation of the many courtesies which were extended and which in many cases were far beyond the requirements of the official duties of the several gentlemen named. This appreciation is due to Capt. F. F. Stewart, of the Coast Guard steamer *Masbate,* for much information and for assistance in embarking and disembarking the party and equipment; and to Mr. William A. Reed, governor of Lepanto-Bontoc; Messrs. Kane, supervisor, Moir, fiscal, and Travis treasurer, of the same province, for their uniform courtesy and assistance. To Señor D. Martin Mills, for his cordial and unfailing hospitality and much information, and to Señor Don Augusto Fuster, administrador de las Minas de Cobre, Mancayan, for valuable data concerning the past condition of the Mancayan mines. To Messrs. Gaffney and Henry Reeder, who, at the advent of the Mining Bureau party, were the only American miners at that time in the district, the writer is indebted for a great deal of information and aid, most of which, without their guidance, would have been missed. These latter gentlemen gave their services freely as guides in the various

Photo by A. J. Eveland.

ON THE OLD SPANISH ROAD, MANCAYAN.

explorations, during many days. To Mr. William Woodward thanks are due for the use of a substantial house in the latter part of the survey, in the inclement weather; and lastly, but by no means the least, to the many officials, provincial and local, of the regions through which the party passed, and who in every case gave all the assistance in their power.

Chapter II.

HISTORY AND PRODUCTION.

The history of the Spanish mining enterprises, whether in the Philippines, South America, or Mexico, is invariably interesting. The story of the mines of Mancayan offers no exception to this, and in view of the present development of the district it is believed it may be of sufficient importance to be given briefly here.

According to the previous writers,[1] the attention of the thinking public of the Philippines and Spain, and especially of those interested in the mining industry, was for a long time drawn to the northern portion of Luzon as a possible source of mineral wealth, as there appeared, and in some abundance, pots and other implements of pure copper which were said to have come from there. Santos in his report[2] says:

> Even in some of the most ancient histories of these Islands (Philippines) copper is cited, among other metals, as one of the products which nature affords with considerable abundance, the natives of the mountains utilizing it for arms, ornaments, and in a profitable business. But the most noteworthy document, which claims attention by its official character and its exactness, as later is verified, is the communication to the governor of his excellency the captain-general, D. Pascual Enrile, of the 20th of June, 1833, in which he states that the utensils that the Igorrotes of the rugged mountain ranges which separate the Province of Cagayan from that of Ilocos make of the copper from the mines have been known for several centuries. * * * With this communication was sent minerals, bars, and spikes of the metal mentioned, which, assayed in the dirección general de minas, gave such good values that not only was it recommended that means be adopted for the exploitation of so much mineral but it gave rise to the creation of the inspection of 1838 and the mining law of 1846.

From such sources as these it became evident that valuable mineral deposits existed, and in 1850 it culminated in the sending of a military expedition into the region to make an investigation, a show of force being essential to Spanish exploration.

With this expedition was sent D. Antonio Hernandez, one of the government engineers, to make an investigation of the deposit, map routes to it, collect specimens, and in general obtain as much information as

[1] Hernandez, Antonio: Reconocimiento de un Çriadero de Cobre en el Monte Aban, Termino de Mancayan, 1850. Santos, Jose Maria: Informe sobre las Minas de Cobre de las Rancherias de Mancayan, . . . en el Distrito de Lepanto, . . . Filipinas, 1862. Drasche, R. von: Fragmente zu einer Geologie die Insel Luzon (Philippinen), 1878; etc.

[2] Op. cit. Translated by A. J. Eveland.

possible for the public. In this regard it is interesting to note the message of the inspector of mines, Señor Sainz de Baranda. He says:[1]

I believe it is my sacred duty to give you a very special command. The mines are situated at a place very distant from all centers of population and the inhabitants of the country, if not at war with the Christians, are not by any means subjugated, and of a savage and ferocious character. I charge you, therefore, do not expose your life imprudently, or your health, for not only the examination and the mines but all of them and all the savages of Pangasinan and Ilocos combined are not worth the life of a Spaniard, and least of all of an engineer of your merits and circumstances.

Hernandez left Manila February 3, 1850, and proceeded to Mancayan via the east coast of Luzon to San Fernando, thence overland to the mines, returning about a month later, having spent seventeen days in mountain travel. His description,[2] preceded by the general narrative of the expedition, is as follows:

Marching from Sugud to the north-northwest to find the valley of the Abra, there is found, after three hours of travel in the territory of Mancayan in the immediate vicinity of the rancherias of Pacpac and Tavio, a deep glen where runs the Arroyo Tavio or Magamban. This glen is bounded on the north by the mountain Aban, on the south by the Sapit, and on the east by the Tavio, more extensive and elevated than the other two. In the southern side of the first is presented a cut or face of 60 or 70 feet in height and 190 or 200 varas (600 or 650 feet) in length, caused by the landslides which have been produced by past excavations in the middle of the declivity, and the constant action of the atmospheric agents, showing in places a considerable mass of compact quartz with pyrite of iron, whose limits can not be figured, because it is seen to be covered by soil, not presenting apparent stratification, but broken and full of fissures on all the surface; some parts are filled with decomposed quartzose or earthy substances stained generally by oxides of iron or carbonate of copper, and others, although in lesser number, hung with small crystals generally of barite.

The quartz carries in some places gray copper, now intimately disseminated in the mass of the rock in the same manner as is the pyrite of iron, again in small veins from two to three fingers in length, and finally in irregular cavities and in pockets of no great extension. Sometimes the mineral is found compact with the quartz without any appearance of continuity; at others filling more or less completely the crevices of the rocks, leaving several fissures or species of geodes with marked crystallization; and in others finally, and this happens in preference in the masses of larger size, it is found separated from the quartz by well-marked bands of gouge or selvage, of a species of fine clay and of great whiteness, although frequently stained by the green carbonate of copper.

Over the larger concentration of gray copper which is presented to view there has been opened a species of irregular excavation of some 4 varas (13 feet) in depth, and in one of the sides is found a face ot the mineral 7 feet in width and 10 in height, terminating in the foreground in selvage and empacked in a tereno summarily weak and decomposed. This being under the surface covered by rocks and fragments of quartz, it is impossible to see where or in what form it is extended; in a like manner the cut of the excavation does not permit of judging

[1] Translated by A. J. Eveland.

[2] Translated by H. D. McCaskey, Chief of the Mining Bureau.

(*a*) First roasting.

Photos by A. J. Eveland.

(*b*) Completion of roast.

IGOROT COPPER SMELTING.

(a) Clearing the matte.

Photos by A. J. Eveland.

(b) Roasting the matte.

IGOROT COPPER SMELTING.

as to the extent of the deposit either in length or depth, seeing only that it continues to the interior of the mountain and to the bottom of the work.

The mineral pertains to the kind called "tenantite" (tedrahedrite?) or arsenical gray copper, being a sulphide of copper, arsenic, and iron, and containing above 44 per cent of copper, 29 of sulphur, 18 of arsenic, and 9 of iron, and not including the silica, which is found mechanically mixed and therefore in variable quantities. This species, which is that which constitutes the deposit, is found in a mass, somewhat crystallized, and with the crystals there are found, although in small quantities, small portions of pyrite of copper, anhydrous crusts of silica, tablets of barite covered by crystallized quartz, and some pyrite of iron. The matrix is compact quartz with some barite, and many specimens offer the aspect of a breccia of quartz with cement of gray copper.

The works, which consist only of holes or small caves of few varas in extension, are found scattered over a distance of approximately 180 varas (600 feet). And judging by the considerable quantity of wash which covers the ground to the arroyo, and the cut which is seen in the side of the mountain, attended on the other hand by little present activity of works, it is to be presumed that the exploitation of this deposit dates back to a very ancient period. In the beginning they probably worked on top of the site where they are now working, and by degrees, after having exhausted the mineral immediately under the surface, have gone lower toward the arroyo, thereby precipitating, little by little, through lack of system, a considerable mass of rock, which has removed a large part of the ancient works; nevertheless, there are yet preserved parts of it of greater extent than those which are now worked.

To open a work the Igorots commence to collect water in a kind of pool or basin which they have formed on top of the declivity, letting it out through one opening, thus causing to fall with considerable violence a mass of water, uncovering the mineral, and indicating the more appropriate places for exploitation. The excavations are executed by means of fire. Placing a little wood fastened to the wall, they ignite it and the following day the mass is found split, which they easily separate from the copper by crushing with stones.

Although the mass of the deposit is a compact quartz very consistent, it is full of fissures, which makes it necessary to support it, and for this they employ small logs of pine which they place in irregular numbers at the places threatening ruin; notwithstanding this, there is no mine which offers even half a security, and several mishaps caused by cavings have already occurred.

TREATMENT OF THE ORE.

The mineral after being extracted from the mine is submitted first to a roasting, or, better yet, a crude melting; for this the natives open in the ground a hole one cuarta in diameter by two or three fingers deep, which they cover with some thin sticks forming a gridiron, above which they place a small, compact heap of mineral, held down by a board or piece of tree; and they cover all with thin pine wood, leaving a protected hollow above the board. They ignite this at once, leaving it alone until it has consumed the wood and completely heated the sulphur of the mineral, which takes two or three hours. The products are an impure mass of copper mixed with earthen substances and pieces of coal and scorias of quartz which offer the aspect of a breccia in which the cement has partly disappeared, converting it into a porous mass.

The copper matte then suffers a melting process for black copper, which they execute in the following manner: They make a hole six or eight fingers in diameter which they surround with stones forming a species of hearth or crucible,

leaving an open space for the placing of a pipe connecting with a cylinder bellows. This consists of two cylinders made from a hollowed trunk of pine in which run pistons formed by blocks of wood dressed on their circumferences with dry herbs and chicken feathers, which are held down only by the bellows, so they work in the manner of springs against the interior surface of the cylinders. In the lower part there is a hole and in that they place a cane, closing the valve at the beginning of the stroke.

Having formed the oven in this manner they charge it with pine fuel, mixed copper and matte, and put the bellows in motion, taking care to add the fuel in proportion to its consumption, and to agitate little by little with a cane so the copper may fall to the bottom and be cleaned from the foreign substances with which it may be mixed. When they know that the copper has all united into one mass, which should take place after ten or fifteen minutes, they stop the bellows and take out the coal and scorias which overfloat the metallic bath, leaving it uncovered until it has hardened a little and acquired sufficient consistency so that it may be handled. The product is a cake of black copper of rough and broken surface full of earth and pieces of fuel.

This cake they place at once on a bonfire, where they leave it two or three hours, making it suffer a kind of roasting process which purifies it somewhat, and they afterwards melt it in the same furnace, placing it in a species of crucible or mold of refractory clay. At the end of this they put the crucible in the hole and over it they place the stone cover and surround it with fuel. They then force a blast, and after the copper is melted they uncover the bath, taking out all the impurities. They remove the crucible from the furnace, and later, when the mass has commenced to consolidate, they compress it with a stick. Finally they take the cake from the crucible, bury it in ashes until it has cooled, and smooth its surface a little by striking it with a stone.

The copper obtained in this manner they sell partly in cakes to the Christian people in the lowlands, and partly dedicate to the manufacture of pots and boilers which the Igorots forge with stones; also making of the same metal bars, tongs, and small pipes for smoking.

There remains now to consider the deposit of copper of Mancayan from an industrial point of view. According to what we have already said, the operations practiced up to date are all very superficial, and we do not believe they authorize the fixing of an opinion with respect to their importance. We are only able to say that the copper deposits pertain to the class of irregular deposits, and that, like the study of the laws which follow the distribution of the mineral, they demand a more mature examination and other methods of observation than the very limited ones which we have been able to make. Interesting above all is the inquiry as to whether the mineral penetrates to the interior of the mountain Aban, and whether the discovered masses in its declivities are only indications of concentrates of greater importance; and we believe that that already discovered is sufficient to justify a determination of this point. For this purpose there could be opened a gallery toward the interior of the mountain which could follow the direction of some of the masses to-day in exploitation, and afterwards there could be opened other galleries branching from the first in a perpendicular direction.

Furthermore, this deposit, by reason of its very irregularity, offers itself better to a system of irregular exploitation than to an arranged plan of operations. To undertake this there must first be expenses of some consideration in preparatory work, which besides their costliness will have to be of slow execution owing to the hardness of the rock. Nor should there be disregarded the topographical position of the territory of Mancayan, and the primitive state of its inhabitants.

Photo by A. J. Eveland.

SMELTER SITE, CANTABRO-FILIPINO COMPANY, MANCAYAN.

The report of Hernandez seems to have awakened considerable interest in public opinion, and the Government took steps to improve the output and methods of mining, requesting information from the engineer. The latter recommended several small improvements, and, with the caustic comment from his chief, that "all the instructions and regulations that could be given are utterly useless as being beyond the knowledge and intelligence of the Igorots, and even beyond that of the persons who have requested that they be communicated to the Igorots," Herandez's connection with the mines ceased.

From the date of this report (1850) several years elapsed before the copper district was brought before the public. Then, in 1856, Señor T. Balbas y Castro, made application for the demarcation of the properties. He presents an agreement[1] made in March, 1865, with—

The infidels, Tibaldo, gobernadorcillo of the rancheria of Mancayan; Mendoza, principal man of the rancheria of Tubo; Lancungan, principal man of Balili; Bayaque, of Bata; Tambana, of Bulalacao; Paduan, of Talbac; and Bagnaqan, of Pat Pat (and others), * * * who, of their own free will and accord, without the mediation of either physical or moral compulsion, deception, or fraud, but because they are persuaded of the advantages that are to be attained; after having conference with their subjects, and in conformity with these, they have agreed in abandoning * * * the right they may have to the mountains which form the fissure through which runs the small river of Magamba, which washes the entire deposit of the metal, * * * with the condition that these shall be respected and no work done in the interior of the small caves or mines which each rancheria has in exploitation from time immemorial.

For this concession was paid the sum of 500 pesos (about $200) and the natives were guaranteed employment in the mines at regular fixed rates. This agreement was approved by the Government and a stock company was formed under the leadership of Señor Balbas, which proceeded to open the mines, two pertenencias of 83,000 square meters each, under the Spanish law, being laid out, and preliminary work being commenced in the same year.

PRODUCTION.

While but few figures of the production of these workings are available, those at hand may be worthy of record, and are here given:

Before the Cantabro-Filipino Company took hold of these workings, it is estimated[2] that from 1840 to 1855, during fifteen years, 40,250 pounds of copper were produced, in the form of cakes or made up in various ways, per year, or a total of approximately 600,000 pounds of metal, at a value of 26 pesos per pico, amounting to 117,000 pesos.

The year 1860[3] marks the first actual production, and in 1860 and 1861, 146,470 arrobas (of 25 pounds) of mineral were produced, the

[1] Translated by A. J. Eveland.

[2] Santos: Informe, p. 19.

[3] Obtained, by courtesy of Señor Balbas, from a few of the yearly reports of the Cantabro-Filipino Company.

greatest yield being from the crushers—that is, 64,688 arrobas—with an average content of 5 per cent copper; screenings, giving 9 per cent metal, yielded 9,608 arrobas; and the production of the first and second class mineral, containing 29 and 15½ per cent copper, was 2,380 and 29,201 arrobas, respectively. The rest of the mineral consisted of mixed ores, from various localities, to about 2,200 tons in all.

In 1862, 145,000 arrobas of mineral were produced, or about 1,800 tons; in 1863, 170,000 arrobas, or about 2,200 tons; in 1864, 180,000 arrobas, or about 2,500 tons; giving a total of 666,470 arrobas up to the end of 1864, or approximately 8,500 tons of mineral.

Further production was, in 1866:

Product.	Copper.	Amount produced.	Content in metal.
	Per cent.	*Pounds.*	*Pounds.*
First class	38	7,650	2,907
Second class	20	288,302	57,072
Various, making a total of		2,509,175	234,807

No further figures are available to show the amount of ore produced from these workings. From another place[1] is taken the statement that up to 1874 there were produced by the Cantabro-Filipino Company 2,500,000 pounds of copper as a result of its operations.

In 1875 the efforts of the Cantabro-Filipino Company came to an end and it suspended work. Santos, whom the Spanish Government had loaned to the company for a considerable period of time, died at the mines, and it is supposed that the cessation of the labors of this, their guiding spirit, contributed in no small degree to the reason for the closing down.

The smelter site and the mine openings remained as they were, and the natives and the Chinos for many years reaped a harvest from this ore, smelting and refining the product in a wonderfully skillful manner. Various projects to reopen the mines came to nothing, and finally in 1898 occurred the war with Spain. In the American Army, and especially among the volunteers, which were principally Western regiments, there were many men who had spent long years in prospecting and mining in other regions, and it was not long before the localities in the Philippines reported ore bearing became known; so that it was the most natural thing in the world for those hardy men to penetrate into this and other portions of the Islands in search of mineral, even when the country was, to say the least, dangerous, as many a sharp conflict showed.

Early in 1900, in January, a party of Americans,[2] eight in number,

[1] Centeno: Memoria Geologico Minera de las Islas Filip., 1870, p. 44.

[2] If informed correctly, the party consisted of Messrs. McCauley, Wooodward, McClusky, Harvy, Malton, and Stueber. These were followed by Leonhard, Ickard, Michaels, Whitmarsh, and Gaffney—almost without an exception ex-soldiers.

Photo by A. J. Eveland.

BURIAL PLACE OF THE SPANISH ENGINEER, SR. JOSE MARIA SANTOS.

reached Mancayan, and saw, as they could not fail to do, the rich copper ores of the old mines. Claims were promptly located, and as their knowledge of the district increased, the ground farther south to Suyoc was examined and located. A month later another party came in, to be followed only a few weeks later by another. This made the district well populated in comparison to its former status, and, according to the Western (United States) customs, a "mining district" was formed and rules drawn up, even though no one knew what mining laws would prevail. For this and other reasons, owing to the unsettled nature of the Islands and its people, but little was done toward exploitation for a year or more. When the laws were promulgated and the attention of those willing and able to help was attracted, development was started in earnest, under the severe conditions which prevail. The future of this and other districts of the Islands will have much to be grateful for—to the courage and skill with which these pioneers (no less so because of a warm climate, and in modern times) forced their way and opened a way for others to follow.

CHAPTER III.

GENERAL.

GEOGRAPHY.

From the index map (Pl. I) it will be seen that the Lepanto copper area or that of Mancayan, the most important district, lies almost directly north of Manila, the barrio of Mancayan being in latitude 16° 53′ north (determined in the field) and approximately the same longitude as Manila. The latitude and longitude of Mount Datá, which is only a few miles to the east of Mancayan, is given by the Spanish authors as latitude 16° 57′ and longitude 120° 55′ west; and of Cervantes, the capital of Lepanto Province, from the same sources, latitude 17° 01′ 10″ north and longitude 120° 50′ 30″ east, approximately.

The region as a whole is in the extreme southern end of Lepanto, on the western slope of Datá, the latter a noteworthy eminence among the lesser peaks of the Cordillera de Solis. Datá, the divide between Benguet and Lepanto, and the Malaya Range form a rough basin, in which the Abra River has its origin, and on the western and northern borders of this basin the mineral-bearing ground has been exploited.

To the south lies the northward-reaching angle of Benguet and the valley of the Agno River; on the east, Datá separates Lepanto from the Asin Valley; on the west is the Malaya Range, with the valley of the Abra.

The scene of the most active work is centered at the barrios of Mancayan and Suyoc, and in their immediate vicinity. From Cervantes south to Mancayan is by direct line a trifle over 9 miles, the trail with its windings bringing this distance up to between 12 and 13 miles (about 19 kilometers). From Mancayan southeast to Suyoc is a little less than 4 miles (6 kilometers) by air line, the divide between the provinces of Lepanto and Benguet being a mile or so farther south. The exploration and development of the copper and gold deposits have been undertaken several miles south of Suyoc and for a mile or more north of Mancayan, in a belt of varying width—at its widest a mile or two—this giving an area under actual attention of 7 miles in length by 2 in width—14 square miles (35 square kilometers).

There are at present two routes to the district. The northern route, from Candon on the coast, via Salcedo, Concepcion, Teila Pass, Angaqui, and Cervantes, is a horse trail which during the dry season is in good

condition. Its difficulties consist of the steep ascent and descent of Teila Pass, and the amount of fording necessary between Salcedo and Concepcion, thirteen crossings of the river being necessary. In the rainy season the muddy condition of the trail from Candon to Salcedo, the flooded condition of the Balidbid River between Salcedo and Concepcion, and the destruction of the trail beyond practically closes this route. Another trail, a few miles to the north, from Angaqui to Santa Maria is an alternative evil. There is contemplated a new trail from Cervantes directly across the Malaya Range, down the Chico River to Tagudín, which it is believed will relieve the present conditions. This trail will shorten the journey from the coast to Cervantes and it is believed will be available during the rainy season.

The trail to the south, to Baguio, is a good horse trail, but also has the disadvantages of the numerous fords which characterizes all island travel. Baguio may be reached in from three to six days, passing via Bugias, Kabayan, Adoway, Daklán, Ambukláo, and Trinidad, and from Baguio or Trinidad two days more are necessary to reach San Fernando on the coast. At this writing there is completed, or at least open to travel, the new Benguet road—a graded carriage road from Baguio to Dagupan, the northern terminus of the railway.

The most available route, therefore, is at present by the northern trail, subject to delays and mishaps in the rainy season.

In the mineral district the main trail from Cervantes, Lepanto, to Benguet passes directly through Mancayan and one-half mile east of Suyoc. Another well-kept trail leads eastward from Mancayan into the basin on the west flank of Datá known as Balili, about 3 miles. Apart from these, there are no trails other than those of Igorot construction. These trails—footpaths over which the Igorots trudge contentedly over impossible grades in single file—form connecting links between all barrios, and are found on every ridge; while they give fair communication among the natives, they offer no solution of the transportation problem.

CLIMATE.

No meteorological data are available for the Province of Lepanto alone, but it may be said that, in common with the whole Philippine group, generally only two seasons are recognizable, the wet and the dry. From November to April the climate of Lepanto leaves little to be desired. At this time of year clear weather predominates, only the occasional mountain showers breaking the long dry season.

At the altitude of Mancayan—the highest knoll in the village being little short of 4,000 feet—the temperature is comparatively low, blankets being comfortable if not actually necessary at night, and on the upper slopes of the southern end of the Malaya Range it is affirmed that the vegetation is killed at periods by low temperature. On good authority

Photo by Martin.

TEILA PASS.

Photo by A. J. Eveland.

it is stated that actual frost has occurred. As late as July (in 1904) it is a fact that three natives died of cold and exhaustion while crossing the Malaya Range at about the same altitude as Mancayan. The mean annual temperature (for Manila) is between 26° and 27° C. (approximately 80° F.). These figures are considerably lower in Lepanto. In general, April, May, and June are the hottest months, followed by the steady rains of the period up to October and November, the entire rainy season coming between the months of May and October.

VEGETATION AND TIMBER.

As in all tropical areas, the native vegetation of Lepanto is heavy and luxuriant. The slopes are heavily covered with a growth of tree ferns, canes, grasses, and small brush, and it is only on the top of ridges that clear spaces are met. The grass of the region is a long, tough, and rank-growing variety, which, unless kept down by burning off, is not particularly good for fodder. The various varieties of cane find a multitude of uses—woven in a variety of ways for almost all conceivable purposes and for construction and clothing. Of the canes the true rattan or bejuco is not found to a large extent in this section of Lepanto. These two of the smaller growths are by far the most important, as the intermediate and useful bamboo is, in the area, not found in any but very small amount.

Of timber proper the notable examples are pine and oak. It may be noted that, according to the older residents of the district, at one time the valley of the Abra River and the adjacent slopes supported a heavy growth of pine and narra (*Plerocarpus indicus* Willd). At present there is hardly a stick of timber in the entire region within a radius of 10 miles of Cervantes. On the lower slopes, near the cultivated land, no timber whatever occurs, and it is only on the more inaccessible portions of the Cordillera del Malaya and the upper portion of Mount Datá that anything like good timber exists. The valley is but another instance of the shortsighted policy of destruction of forests when proper care is not taken, and without the slightest doubt the absence of retaining timber over this drainage area has a considerable effect on the run-off and the condition of the rivers in the flood seasons. Much of this timber was consumed by the smelters of the Cantabro-Filipino Company in their operations, and at present a demand for timber would necessitate a 2 or 3 mile haul for a small amount, and if heavy demand were made on the forests for such purposes as fuel a considerably greater distance would have to be reckoned upon. The pine growth is of good size, clear and straight, up to about 2-foot (diameter) sticks. On certain portions of the higher ridges a moderate oak growth is met. This latter is heavier south of the mineral region, in Benguet Province, but, in necessity, fairly accessible.

AGRICULTURAL.

Aside from the timber products, and the natural wild growth common to all tropical regions, Lepanto offers along certain agricultural lines considerable opportunity for development.

In all portions several varieties of the banana are plentiful, serving as a food product. The coffee, especially in the higher regions (above 3,000 feet), is of most excellent quality, and at one time large areas were under cultivation that are now given over to grass. Cacao has been tried and successfully cultivated to a considerable extent. Sugar cane on the lower portions of the area, such as the flat at Comillas, yielded in past times exceptionally good returns; and the staple product, rice, reigns supreme. The labor and care given to this particular crop by the Igorots is something prodigious, in the construction of the paddies alone. Terraces to heights of 1,000 to 1,500 feet are not uncommon, and flumes, sluices, and dams are everywhere in evidence. The bulk of the product that is not consumed on the ground is not shipped out to the coast for export, but, on the contrary, into the interior to less fortunately situated peoples. The entire valley of the Mancayan River, as well as the Abra and its other tributaries, is flanked by rice paddies. No estimate has ever been made of the value of the crop annually, but from the number of hogs, dogs, and other merchandise sold by the traders from the coast, the figures must be of large proportion. The camote (a variety of sweet potato) is even more invariably cultivated, as it is the principal article of food. It grows rapidly, bears throughout the year, and requires but little care, conditions perfectly in accord with the ideas of the Igorot.

The natives—that is, the women and children—are engaged in the cultivation of the rice and other crops. The male Igorot does but little manual labor, the cultivation of the camote patches upon which the family depends for food, the rice fields, and other crops being left to the labors of women and children. The resemblance to the American Indian in this respect is striking, the position of head of the family and the state of proprietorship of any cattle or lands he may possess being evidently sufficiently arduous labor for the Igorot. Apart from the occasional mining and smelting done by him, there is little regular industry. The mining in the wet season, the cultivation of the crops, and the care of cattle are the chief employments.

POPULATION.

Within this district lies the large town of Cervantes, the capital of the province, which is the only considerable gathering of population in a town. Others, such as Mancayan to the south of Cervantes, have but little of a collected population. In the total, the number of inhabitants of the district is not inconsiderable, but a view of the country reveals no villages of any size.

The tendency of the Igorot is to collect in groups of at most a score of huts, far up on some almost inaccessible ridge, and to avoid anything like a large village. Within a radius of a mile or two of Cervantes, Mancayan, Suyoc, and Cayan may be encountered numerous small barrios, which bring the population of the province up to 72,750.[1] Cervantes proper has a population of 1,437 civilized, but with its outlying barrios the population, as given in the Gazetteer of the Philippine Islands from the census of 1887, is 16,000.[2]

Similarly in the village of Mancayan are, according to the census of 1903, 118 civilized inhabitants, but its total population is about 1,500. The total population, almost wholly "wild," of Suyoc is 600.

GOVERNMENT.

The present system of government places directly in charge of the province and answering to the Civil Government of the Islands a governor, a supervisor or engineer, a treasurer, and a secretary. These unite as a provincial board and decide as a whole the work to be done. In the various subdivisions are native presidentes (or headmen) and their consejales (or aldermen), and purely local affairs are directed by these, subject to central supervision and command. A group of old men in each smaller village have tacit powers, and it is one of the good points in the Igorot makeup that their word has such great weight.

While it is hardly within the province of this report to enter deeply into racial characteristics, a very few words as to the nature of the inhabitants of these mining districts may not be out of place.

The Igorot is somewhat sharply distinct from the other races of the Islands.[3] He is supposed to be derived from the races of the Malay invasion which were driven inland by the later invasion from the same region. He is a sturdy savage, generally happy and content, of considerable intelligence and good disposition; from a racial standpoint, moral and honorable. He takes not kindly to labor, not from the inherent mistaken idea of the Tagal, who despises work as degrading, but from the fact that he is of the mountain, free and untrammeled, and much labor is not necessary to his existence. He is more hardy than his brother of the coasts and plains, and as further more inaccessible portions of the island are reached many fine specimens of men and women are seen.

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[1] Of this number 70,283 are classified as "wild" and 2,467 as civilized. Census of the Philippine Islands, 1903.

[2] The census of 1903 gives no total figures for towns and barrios, so that this figure must be accepted, though of doubtful value.

[3] See Virchow, Rud.: The Peopling of the Philippines, 1897; and Jenks, A. E.: The Bontoc Igorot, Volume I of the Ethnological Survey Publications of the Government of the Philippine Islands.

In religion his ideas are crude and have more or less of an oriental tinge—in fact, a mixture of the Shintoism of Japan with the belief of the North American Indian could not be far from the religion of the Igorot. Crude as the belief may appear to Christians, it is nevertheless a religion, a belief in a spiritual authority. The respect and deference accorded to the old men has been already commented upon; the Igorot feels a moral obligation to care for his aged that is rarely exceeded.

In advancement the Igorot is a curious mingling of the most ancient and the quite modern. The agricultural implements in use are the most primitive of iron instruments, and the pointed stick is in common use. The flint-and-steel method of making fire is used in certain parts of the province, and in others the "fire gun"—a tight-fitting piston in a barrel heating the compressed air—is the means used. In his copper smelting the process used is extraordinarily in accordance with modern practice, and yet in casting objects of gold, bronze, or copper the "cire perdue" process is used, a method which is also practiced by the Burmese bell founders, and which has come down from the Bronze Age. The use of a blast cylinder is common, superseding blowing by mouth, or a bellows; the pan for washing gold is of superior pattern; and the native has progressed far enough in construction to build an arch, though a "false arch," formed by courses of stones projecting inward, one course above another, and not the more advanced type, the "true arch," of the keystone; and yet the Igorot has faith in the trial by ordeal and reckons the passing of time by the height of the sun and longer periods by the recurrence of the moon, and by the number of harvests.

ROM TUBOC. MONTE DATA IN BACK

Photo by A. J. Eveland.

TOPOGRAPHY ON GILONG CREEK.

Photo by A. J. Eveland.

MANCAYAN RIVER VALLEY.

Photo by A. J. Eveland.

MANCAYAN RIVER VALLEY.

Photo by A. J. Eveland.

ABRA RIVER AT COMILLAS. EASTWARD VIEW.

CHAPTER IV.

TOPOGRAPHY AND HYDROGRAPHY.

TOPOGRAPHY.

Northern Luzon, above the sixteenth parallel of north latitude, presents fairly uniformly a single topographic type. It is characterized by parallel approximately north-south mountain ranges, with extensive longitudinal valley systems. Broadly speaking, almost in the center of the island is the main chain, the Cordillera Central, and its extensions, the Cordillera del Norte and the Caraballo Sur, which forms the main watershed of Luzon. Two coast ranges, the Sierra Madre of the Pacific coast, and a series of somewhat irregular ranges on the west coast, under a variety of names, mark, with the main mass shown the roughly parallel system of mountain range and valley. From the central cordillera transversal valleys modify the regularity of the structure, and present, in central northern Luzon, a broken and irregular appearance, the region immediately to the east of the Cordillera Central being particularly irregular.

Denudation is the keynote of the topography, and although the immediate east and west boundaries of the area more closely connected with the territory under mining investigation depend to a greater or less extent on the structure, the limiting ranges on the sides being tectonic in type, late volcanic action and extreme degradation have combined to produce topographic forms unclassifiable under one head.

The regions of Mancayan and Suyoc are at the head of the Abra Valley, which has resulted from the breaking down of an anticlinal arch of wide extent, and possibly, to some degree, to faulting of the same.

On the west of this valley lie the Cordillera del Teila, an escarpment of westward-tilted sedimentaries rising some 4,000 feet above the level of the sea, and here on the east, having a precipitous slope to the valley of the Abra (at Angaqui), at the foot of Teila Pass, of 3,000 feet.

On the east the main watershed of the Cordillera Central marks the boundary of the province, and similarly this range is flanked on the east by tilted sedimentaries. The valley is terminated at the south by spurs in a northeasterly direction, which also mark the boundary of Lepanto Province.

The topography of the immediate area of the mineral exploitation is therefore of a limited area only—that of the head waters of the Abra River. Situated as this district is, on the flank of Mount Datá of the

Cordillera Central, and closely surrounded by the limiting ranges, the topographic forms are dependent to greater measure upon drainage and subsequent degradation than upon structure. The sedimentaries to the west are some little distance from this region, and those to the east, though uncovered by river action only at the immediate eastern side of the mineral district, have been buried by late volcanic material to a considerable depth. Drainage from this region is directed altogether to the north, ultimately, and the generally northern trend of the valleys in connection with the usual radial type of mountain mass erosion produces the resultant deeply eroded surface.

The small area over which mining and prospecting are being carried on rests on the west slope of Mount Datá, and a spur which extends from that mass to the west. As a whole, the slope of Datá to the western side is uniform, forming an irregular conical mass, around the base of which runs the Abra River and its tributaries. On account of rainfall conditions the erosion has been marked, and steep gorges, V-shaped, are the rule. The upper volcanic rocks of the eastern portion of the region are of a yielding nature, and erosion produces rounded forms, "hogbacks," and mounds, giving a quite regular slope to the immediate base of Datá; further to the west, where the rock masses are harder, and in the intermediate areas, where the streams cut through into the hard material beneath, the steep-sloped ravines predominate, and the drainage is divided so carefully that ridges and spurs give at the top but space for a foot trail. Lateral erosion has been deep and rapid, and a general topographic map of a large area will show a well-dissected region.

The towns of Mancayan and Suyoc are situated on the top of the less resistant material spoken of and the appearance of the area around them, rounded and rolling, is in decided contrast to the steep slopes and rapid fall of the gorges and river channels at their immediate boundaries.

HYDROGRAPHY.

The region of Mancayan, situated, as it is, on the slopes of Mount Data, is well drained by numerous streams, chief among them being the Abra and its tributaries. The course of the Abra proper is somewhat peculiar. It rises a little south of Mancayan, flowing in a *southern* direction, for a short distance, describing a semicircular course, through well-cut, V-shaped gorges to Comillas, northwest of Mancayan. From there on the course of the river is normal, winding through the broad valley between the Cordilleras de Teila and Solis.

Starting from Tuboc, the barrio nearly in the center of the district, the Mancayan River cuts an almost straight path to its junction with the Abra at Comillas. At a short distance from its origin it is entered on the east by the shorter stream known as the Mangambang, or Tabio, which rises on the Aban spur of Mount Data, and cuts the gorge of some 500 feet

Photo by A. J. Eveland.

ABRA RIVER AT COMILLAS.

Photo by A. J. Eveland.

FLOOD PLAIN OF ABRA RIVER AT COMILLAS.

THE MINING BUREAU.

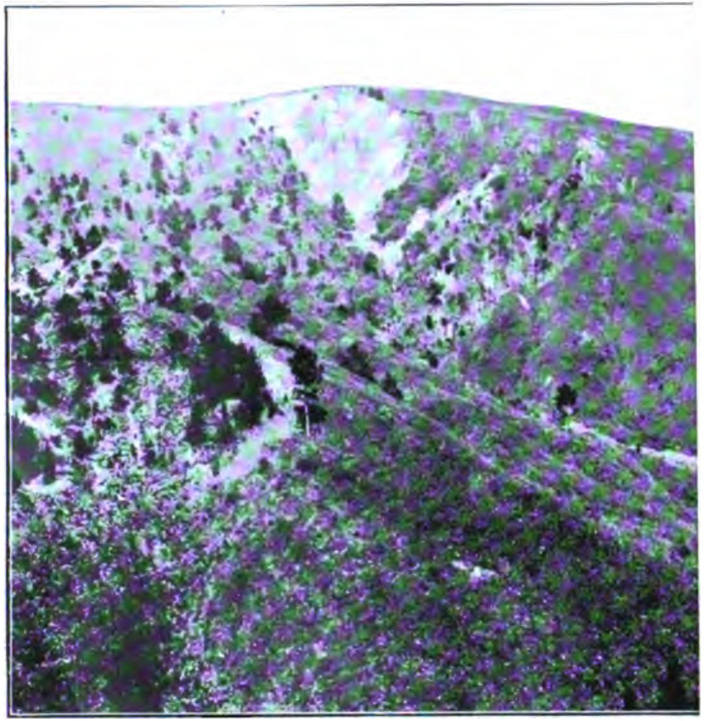

Photo by A. J. Eveland.

Photo by A. J. Eveland.

MANCAYAN RIVER VALLEY ABOVE BUGIAS.

Photo by A. J. Eveland.

MANCAYAN RIVER AT BUGIAS.

through the deposits of copper at Mancayan. Farther to the east, on the upper slopes of Mount Data, the river early develops power, and, flowing westward for 1 or 2 miles, turns abruptly to the north at a right angle, and finally debouches into the Mancayan at Baguis, 3 miles above (south of) Comillas.

The River Maanse has its origin south of the Mangambang, or Tabio, on the same spur (Mount Aban), flows west to Tuboc, thence south to Cayan, where it is met by the gullies draining the northern side of Suyoc Hill, and then in a westerly direction pursues a winding course through steep, V-shaped gorges to the Abra, several miles southwest of Suyoc.

The topography and geology of the region have affected the drainage to a considerable extent, as will be spoken of later. The rivers north of Mancayan present the usual condition of mountain-river type—the torrential water course, heavy falls, a swift, deep-gorge-cutting stream debouching into the broad valley below. But south of Mancayan irregularities of drainage are met with that indicate certain orographic changes and influences due to the nature of the rock masses.

All the rivers of the region could be described as in first and second stages of development, with steep declivities. They are to considerable extent dependent upon the seasonal changes for their volume and show large variation between extremes. During the dry season, only the springs and the "old" water keep up the volume. There is a very great diminishment in volume and power, though the streams do not by any means run dry. From the beginning of the rainy season the river steadily increases in size, and becomes, after the occasional, long, steady torrents of rain, tremendous confined floods. Until the water reaches Comillas there is, in the case of the upper valley of the Abra, no chance for expansion over any considerable area, and in consequence the rapidity and power of these streams is something astounding. Streams which were but knee-deep and a few feet in width become torrents that a horse can not ford. Under these conditions erosion has been rapid and has its effect in the topographic form.

The Abra River waters above Suyoc and those of the Bat-Bat River to the east are hardly potable from the viewpoint of the European while the streams heading up in the mineral region, as the Maanse, Pacat, Mancayan, are extremely bad. A great amount of copper and iron salts is present, as well as arsenical soluble salts, and certain springs are quite poisonous. At the meeting of the Mancayan River, which is very clear, and the Mangambang River, slightly milky and brownish, there is deposited a vivid blue film or coating in the bed, which diminishes in intensity for fully 2,000 feet downstream, and the vivid blue color of the water and of the blue-coated bed produced by the chemical reaction is plainly discernible from the tops of the surrounding ridges. The explanation of this unusually strong reaction lies in the fact that the

Mangambang River, as heretofore stated, cuts directly through the deposit of the copper minerals, of the old mines, and the Upper Mancayan River drains an area more or less shattered and decomposed, with a great deal of altering iron sulphides.

The occurrence is so striking that in previous times it certainly should have been and probably was an index finger to the prospector.

There are, however, many springs among the extraordinary number with which the district is watered, a number of which give cool, clear, and pure (no analysis made) water. These waters are fairly potable.

Hot springs, while not flowing in the immediate area under consideration, are prevalent all through this mountain region. In the Province of Benguet, some 40 miles to the southwest, there are numerous active springs, which are sufficiently large in volume and temperature to be worthy of considerable attention. And in Lepanto Province, to the north of Mancayan, there exists a similar region. The nearest of these occurrences is at Comillas, less than 10 miles northwest of Mancayan on the trail to Cervantes, where the trail crosses the River Abra. Here there is a small hot spring which has been described by Centeno, under the Spanish régime, as a ferruginous sodium-chloride spring.

At Cervantes, in the flood plain of the River Abra, by which it is covered at periods of high water, are several springs, or, in all probability, several vents of the same spring, within a comparatively few feet of one another.

On these springs, as well as many others of the Islands, the Spanish Government made more or less extensive reports, and the following excerpts are chosen from the reports mentioned, as of some value. Of the Comillas springs, Centeno[1] says:

> It gushes out of an ancient wash of angular dioritic and other eruptive rocks, forming a small pool at the river, in which, notwithstanding the high temperature, which the human body hardly can bear, the Igorots are accustomed to bathe, with good results in the great variety of cutaneous diseases to which they are subject. From this comes the great faith in their waters, that these poor people have. Guided as they are by superstition in almost every act of their lives, they never bathe here without invoking the favor of the "anitos" of the spring, making a modest offering, which generally consists of a little "palay" or rice, which they throw into the pool.

Centeno gives the height of this spring as 460 meters (1,518 feet) above sea level; from the recent survey it is approximately 1,400 feet. A flow of 1.43 liters per second was recorded, or 123 cubic meters in twenty-four hours. The water is clear, transparent, inodorous, and tastes salty; neutral reaction on litmus; no gaseous emanations; temperature of the water, 50° C. (the air, 26° C., December 17, 1886); density at 0° C. and 760 millimeters is 1.004375.

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[1] Memoria Descriptiva de los Manantiales de la Isla de Luzon. D. José Centeno (et al.), Madrid, 1890.

Photo by A. J. Eveland.

TOPOGRAPHY IN THE VICINITY OF CERVANTES.

Photo by A. J. Eveland.

TOPOGRAPHY ON MAANSE RIVER.

THE MINING BUREAU.

Photo by A. J. Eveland.

Analysis of 1 liter of the water is as follows:

Content.	Weight.	Content.	Weight.
	Gram.		*Gram.*
CO_2	0.060000	CaO (in the decanted liquid)	0.086016
Ca_2O (precipitated by boiling)	.006720	Na_2O	.268849
Mg_2O (precipitated by boiling)	.006882	LiO	Trace.
FeO (ferroso) (precipitated by boiling)	.Trace.	So_3	.132582
SiO_2	.074400	Cl	.316655
FeO (in the decanted liquid)	.180000		

Residue obtained by the direct evaporation of 1 liter of water and dried at 180° C. (approximately) weighed 0.851000 gram. It is calculated from the analysis that 1 liter of water at 50° C. contains in solution:

Content.		Weight.	Content.	Weight.
	Cubic centimeters.	*Gram.*		*Gram.*
O	3.965000	0.005669	$FeSO_4$	0.018389
N	7.930000	.009961	NaCl	.506678
CO_2 (free)	17.556375	.034669	LiCl	Trace.
$CaCo_3$		.017280	FeCl	.016427
$MgCo_3$		.021653	SiO_2	.074400
$FeCO_3$		Trace.		
$CaSO_4$		.208896	Total	.913972

The Cervantes spring issues from the margin of the river, at a height (Centeno) of 435 meters above sea level, at a rate of 0.24 liter per second.

The water is clear, transparent, uncolored, inodorous, with a slightly salty, hard taste. It gives out bubbles of gas, and the litmus paper shows a neutral reaction. The temperature of the water is 56° C. (air, 25° C.) and density at 0° C. and 760 millimeters is 1.004732.

Anhydrous substances in 1 liter of the water are as below:

Content.	Weight.	Content.	Weight.
	Gram.		*Gram.*
Co_2	0.004000	So_3	0.521888
SiO_2	.032000	Cl	.335456
CaO	.237440	Al_2O_3	Trace.
MgO	.005125	$CaCo_3$	Trace.
Na_2O	.426687	Organic matter	Trace.

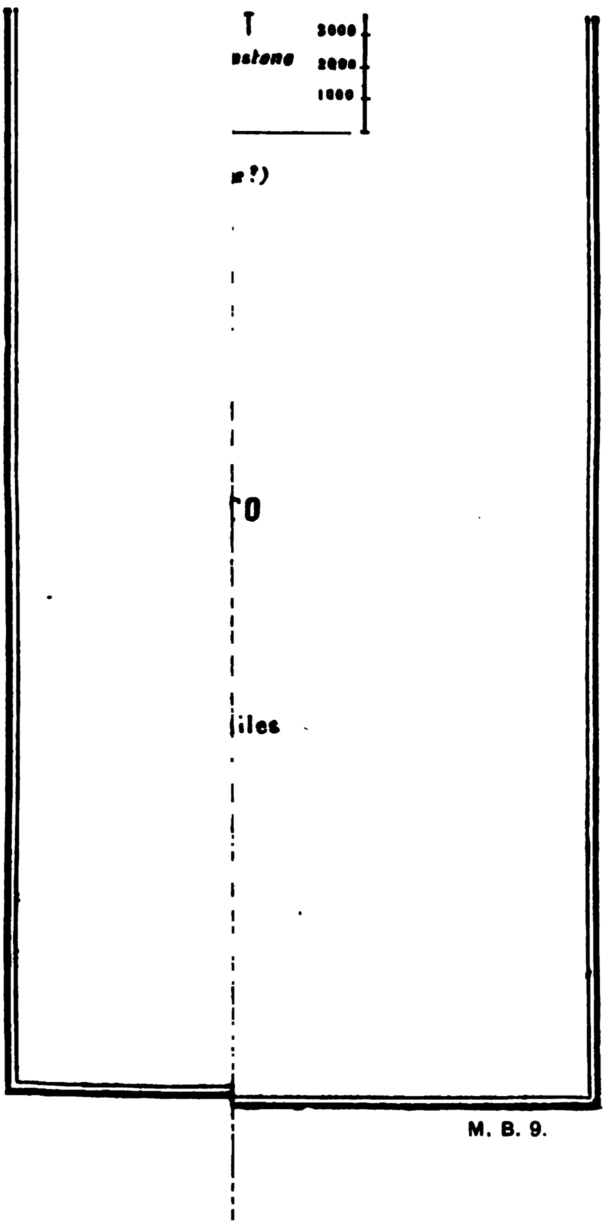
Residue obtained by evaporation of 1 liter = 1.483000 grams.

Resulting from the analysis, it is computed that 1 liter of this water at 50° C. contains in solution:

Content.		Weight.	Content.	Weight.
	Cubic centimeters.	*Gram.*		*Gram.*
Co_2	2.025598	0.004000	$CaCO_3$	Trace.
Air	10.689488	.013828	SiO_2	0.032000
$CaSo_4$		.576640	Al_2O_3	Trace.
Na_2SO_4		.324147	Organic matter	Trace.
NaCl		.538121		
MgCl		.012000	Total	1.500736

Both these springs, it is claimed, have a decided medical value, and are largely used by the natives both for bathing and drinking purposes.

At Angaqui are other springs of a sulphurous nature, and in the eastern portion of the province are also many saline and hot springs, all of which constitute a feature of this and much of the rest of the Island of Luzon.



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CHAPTER V.

GENERAL GEOLOGY.

LOCAL AND STRUCTURAL.

The geology of the limited area in which ore deposits are found is dependent, similarly to the topography, to a considerable extent on the general conditions of northern Luzon. Up to date but little has been known of the geologic conditions north of the central plain of Luzon, and, aside from disconnected notes made by occasional visiting geologists, the geology of the entire northern part of Luzon was mere conjecture. The Spanish authorities made an occasional visit to certain localities, one of which (Hernandez's inspection of the Lepanto area) has already been noted,[1] and, noteworthy among the others, Mr. R. von Drasche visited this area in 1875 and gave to the public his observations. Before these observations and deductions of Von Drasche, rapidly made but showing a thoroughly trained mind, the views as to the constitution of this part of the island were quite at a loss for some facts to tie to. Semper[2] speaks of the "trachytic core" of the island, and the adjacent and overlying sedimentary strata of recent age. J. Roth,[3] a short time later, compiling the information available at that time, states that "on a formation of crystalline schists" lie the Tertiary strata. Roth's conclusions were drawn from the observed occurrence of schists in the Islands of Cebu, Leyte, Mindanao, and in the Camarines Provinces of southern Luzon, and also the occurrences noted by Itier[4] of stream pebles at Angat, in Bulacan Province.

Mr. Becker in this report,[5] which gives us the most complete and concise statement of all known information, draws the inference that the crystalline schists are predominant in the basal mass of the Islands; and reasoning from analogous conditions in Borneo, and the observed facts of the known occurrences of ore deposits associated with schists or crystalline massives, he so summarizes the previous observations.

From the slight amount of work already done it seems probable that the schists do not occupy as important a place as taken for granted by Mr. Becker, but that, as Abella generalizes,[6] the diorites and dioritic

[1] See page 15.

[2] Die Philippinen und ihre Bewohner. 1869.

[3] Constitucion Geologica de Filipinas.

[4] Bull. Soc. Geog., Paris, 3d series, Vol. V, 1845.

[5] Geology of the Philippine Islands, 1901, U. S. Geological Survey, Twenty-first Ann. Report.

[6] Apuntos fisicos y geologicos. 1884.

rocks in general are the oldest rocks, at least north of the great plain of Luzon. As far north as the Province of Abra, my observations have borne this out, and in this region, west of the Cordillera Central, no schists have been observed.

From the west coast of Luzon, particularly at Candon, the point on the coast at which the party disembarked, to the Cordillera Central, at the mass of Mount Data, the general relations of the rocks are as seen by a reference to the ideal section.[1] The sedimentaries outcrop a mile or so east of Candon, at that locality dipping 40° northeast; between Candon and Concepcion gentle folding has taken place, and the valley of the Balidbid River exposes recurrent anticlines and synclines, the region bearing a striking resemblance to the Potomac River valley and others of like type in the Piedmont area in Pennsylvania, Maryland, and Virginia.

At Concepcion, which is situated in a flanking valley at the foot of the west slope of the range, the tilted sedimentaries are a prominent feature of the landscape. Great jagged blocks are tilted up against the main mass of this range, giving the slope a peculiar flat and geometrical effect.

At the crest of the Cordillera del Teila, as the coast range at this point is called, appears a great thickness of limestone, dipping to the southwest, and below it a heavy, thick conglomerate, cropping on the eastern scarp. The upper limestone, of a thickness of hundreds of feet, forms the crest of the range for an unknown distance; no fossils were collected during the hasty march, but in all probability search will reveal some organic remains; Santos quotes Semper as authority for the determination of nummulites from these beds, in abundance, and for the statement that the nummulites "have up to now occurred in the Eocene ('paléo thérico de M. Cordier') or in the immediately adjacent Upper Cretaceous." Becker[2] cautions the geological observer from inferring an upheaval from inclined stratification, but on account of the adjacent conglomerate and slates it is fairly certain that the tilting of the limestone may be traced to structural causes, and that the question of coral growth and pseudo-stratification does not enter here.

The basal conglomerate is also of great thickness, and, while on stratigraphical grounds it may not as yet be correlated accurately, it would appear from the continuity of these sedimentaries, observed from occasional peaks in going to the south through Benguet, and on lithological grounds, that these are the extension of the "Agno beds" of Von Drasche. In the Agno River they are described by Von Drasche as consisting in the lower portions of coarse breccias and conglomerate of dioritic rocks, very coarsely bedded, with pebbles often of enormous size.

[1] Plate XXIII. [2] Op. cit., p. 561.

Regarding the ages of these rocks nothing can be said except the deductions already made by others. In the present work economic problems were of the first importance and these sedimentaries apparently have no specific connection with the ore deposits of Lepanto. Von Drasche[1] first classed them as primitive, then Paleozoic. Later, Abella seems to have obtained fossils in the upper strata, of shells of surviving species, and lignite, and adopts the hypothesis that these Agno beds represent the basal conglomerate formed during the Miocene subsidence of the Philippine group.

Mr. Becker remarks in this connection that "it is tempting to seek in them (the Agno beds) the equivalent of Mr. Verbeek's breccia stage of the Eocene, which consist of unfossiliferous strata underlying Stage a; but the absence in the region of Benguet of the Cebuan lignitic series and the character of the organic remains appear to indicate that this portion of Luzon was above water during Eocene time." It may be possible that the tentative suggestion of this correlation may be later worked out, as it has happened that lately a small seam of lignite has been discovered on the Benguet road in this region. As it was not seen, its relations to the Agno beds are not known, and the coming field season in this area may throw some light on the subject.

The valley of the Abra River is cut, from these sedimentaries on the west to the Cordillera Central, in igneous rocks of various composition. With the exception of an olivine basalt (?) noted near Cervantes, no general lines were followed until the Mancayan district was reached.

Here, after study of the area, the structure reveals an underlying diorite, the occurrence of which again confirms Abella's deductions.

Various igneous intrusions have taken place in the basal diorite, one of the most noteworthy having a considerable expanse immediately west of Mancayan, the Mancayan River roughly following the contact between the two for a mile or more. This mass seems to have no relation to the economic aspect of the region, and, except for a description of the rock (called the Bagan granite, from its occurrence on the mountain of that name), will not be noted further. Other intrusions, and especially a mass at Suyoc, seem to have some bearing on the ore deposits and will be taken up. Except for the more important rocks of those having a direct bearing on the economic problem of this district, geological work on the rocks of this region will be reserved until suitable mapping may be done.

One of the most important masses, however, is the "trachyte" of Santos and von Drasche, which predominate to the east of Mancayan. The basal diorite, named the "Mancayan" diorite from its best exposures in the river of that name, is overlain to a variable depth, by a crystalline, neovolcanic rock, classified, as stated, as sanidine-trachyte by Von Drasche, and by Santos expressed as "porfido arcilloso;" this Mr. Becker translates

[1] I again have to thank Mr. Becker for his valuable résumé of past explorers; from his report is taken most of the following.

as argillaceous porphyry, and interprets as a quartzless, partially decomposed lava. This igneous rock outcrops on the west side of the hill on which is situated the town of Mancayan, and the contact follows a north-south approximation through Suyoc into Benguet. The same rock was observed at the town of Daklán, in Benguet, over 30 miles south, and is evidently some extensive lava flow of late age. Facies of this occurrence were observed on the western slopes of Mount Data, and from the topography and structure of the region it is thought that the source of the outburst should lie to the east. Mount Data has been alluded to generally as an extinct volcano, and mention is made of a crater lake at its summit by Meyer.[1] He states that he ascended Data (in 1882), measured its height by barometer as 2,245 meters, and found a lake 1,100 yards in diameter on a bench on the eastern slope of the highest part of the mountain.

None of those who have given to the public notes on this region have made mention of *sedimentaries* on the west slope of Data. These clays and limestones were observed in a river cutting the base of Mount Data, dipping about 20° to the east. Over the upturned edges of these rocks, which have a section of some 500 or 600 feet exposed by waterfalls, spreads the "trachyte" of Von Drasche, and the upper portion of the mountain is, as far as is known, of the same material.

Judging from the structure, therefore, it is at least open to doubt if the mass of Data, as generally supposed, is the remains of an extinct volcano, or whether Data is the residual mass left by erosion of the eastern limb of the broken anticlinal arch added to by later volcanic action, either intrusive or effusive. It is certain, however, that limestones and a small seam of coal do outcrop on the eastern flank of Data and that at Cayan, or its vicinity, east of Cervantes, the limestone is again met with, these limestones containing numerous forminifera (nummulites), according to Semper.[2] If Data is of volcanic autogenesis, the activity was probably of a laccolithic type, intrusive, and not of the general mountain-building type prevalent generally in the Islands.

ROCKS.

The massive igneous rocks of this locality are represented by diorite, granite, quartz porphyry, trachyte, and one or more varieties of igneous intrusions that are not described. It is unfortunate that many rock analyses and determinations could not be obtained in time to be of service as data for this report, and also that in spite of every effort it was found impossible to prepare thin sections of one of the most important rocks in the district, the "trachyte" of Von Drasche. Due to the decomposed nature of this mass and the somewhat limited mechanical facilities at service, no satisfactory section of this rock is ready, and the additional lack of analyses prevents more than a megascopic description of it.

[1] Weltreise, 1890, pp. 253–287.

[2] That is, if Santos has quoted correctly.

Photo by A. J. Eveland.

LOOKING NORTH DOWN THE VALLEY OF THE NAPAC

Photo by A. J. Eveland.

NEARER VIEW OF THE SEDIMENTARIES OF PLATE XXVII.

Photo by A. J. Eveland.

OLD SPANISH ROAD TO COPPER MINES, MANCAYAN, SHOWING CONTACT BETWEEN OVERLYING QUARTZ-PORPHYRY AND MANCAYAN DIORITE.

THE MANCAYAN DIORITE.

The diorite of this locality, the "Mancayan" diorite, is, on megascopic inspection, a dark-green granular rock, coming well under the field classificatory[1] name of diorite. Within the Lepanto area it is uniform in texture and structure, showing unusually little of the variability of dioritic types. As noted before, the same type is noted in Benguet and other areas, and there are good grounds for believing that the diorite is a widely extended mass.

The relative size of the hornblende and feldspar give the rock its color, and in a hand specimen the amphibole is apparently predominant. On weathered surfaces, however, the feldspar stands out in light-colored lath or rod-shaped crystals, within a matrix of the amphibole. No other minerals are noted, megascopically.

In the examination of the thin sections there is revealed a plagioclase, in rod or lath shaped crystals, involved in a matrix of green hornblende. The plagioclase, as seen on symmetrically cut twins, is apparently labradorite, evidently of earlier formation than the hornblende. This reversal of the normal order of crystallization produces the pseudo-ophitic structure noted. The feldspar is white, cloudy, with dull, earthy luster; no zonary banding observed in the limited sections and no kaolinization to a great extent.

The next important mineral, the hornblende, occurs in flakes and very fragmentary masses surrounding the feldspar lathes; light green in the section and has a low extinction angle which can not be exactly determined, owing to the fragmentary nature of the mineral. No uralitization was noted, though the transposition of gabbros or diabases to this diorite may not be positively denied.

No quartz present, nor mica. Olivine occurs in rounded grains in the hornblende, showing slight alteration. Magnetite also noted, in typical forms.

Four analyses[2] of the Mancayan diorite follow:

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture, 110°	0.50	0.28	0.38	0.12
Loss on ignition	2.74	1.38	.70	2.26
SiO_2	50.67	51	47.98	47.94
Al_2O_3	21.21	18.01	18.94	21.96
Fe_2O_3	11.31	.23	7.08	2.48
FeO	.21	9.31	3.98	3.42
CaO	6.86	8.89	11.01	12.63
MgO	4.10	6.53	7.06	6.83
K_2O	.10	.46	.44	.19
Na_2O	1.41	4.42	2.56	1.49
Total	99.11	100.51	100.13	99.85

[1] Cross, Pirsson, Iddings, Washington: A Quantitative Chemico-Mineralogical Classification and Nomenclature of Igneous Rocks. Chicago, 1902.

[2] Analyses by Mr. L. S. Salinger, Bureau of Government Laboratories, Manila, P. I., 1905.

Analyses[1] of this rock follow:

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	0.02	0.13	0.20
Loss on ignition	.89	.84	1.01
Silica (SiO_2)	77.21	73.56	71.80
Alumina (Al_2O_3)	15.38	1.42	2.46
Ferric oxide (Fe_2O_3)	.72	1.27	1.93
Ferrous oxide (FeO)	.93	14.30	14.28
Lime (CaO)	2.18	2.50	2.96
Magnesia (MgO)	.42	.79	.22
Potassium oxide (K_2O)	.50	.38	1.54
Sodium oxide (Na_2O)	2.26	5.09	3.02
Total	100.01	100.28	99.42

THE QUARTZ PORPHYRY.

This rock, the mass characterized by Santos[2] as "porfido argilloso," or argillaceous porphyry, as Becker translates it, occurs on the western side of the Mancayan hill, resting on the Mancayan diorite beneath. This one outcrop extends a distance of several miles, disappearing north and south under the "trachyte" which covers it at Mancayan. There are to the north several smaller outcrops, isolated masses or islands, and the whole mass has been the subject of considerable conjecture and limited study, having, as it does, a direct bearing on the ore deposits of the copper region.

Santos[3] describes it as "a quartzose mass in a vertical position, not more than 80 or 100 meters in thickness, which strikes northwest, and is exposed at the southeast by a great cut, partly due to the mining operations of the natives. Toward the northwest it is partially concealed and disappears under argillaceous porphyry (porfido argilloso), which is more recent. The siliceous mass is of the same character throughout its extent; it is sometimes compact, sometimes crystalline, often porous, and always charged with iron pyrite. It contains decomposed feldspar in irregular veins, or porphyritically disposed. The croppings are of columnar form. The whole mass is fissured or jointed in different directions." Mr. von Drasche later visited this locality, but could not discover the rock relations. He speaks[4] of the rock as a rhyolitic quartz-trachyte, which shows flow structure, with variations in the color of the ground mass from dark gray to red. In this thick, hard, splintery ground mass are quartz fragments, extremely numerous. They are never rounded nor do they show other than a regular character; they attain a thickness of 4 millimeters. Thin sections gave him no clue to the nature of the ground mass, but he states that it is evident that the

[1] Bureau of Government Laboratories.

[2] Op. cit.

[3] Informe sobre las minas de cobre, p. 25.

[4] Von Darsche, Fragmente, p. 37.

quartz fragments have not come from the ground mass and that they were "wrapped up" by the still fluid magma.

The two descriptions already given cover fairly well the general aspect of this rock—it is a hard, flinty, red to yellow-white quartz leucophyre with prominent quartz phenocrysts. Nothing can be made of this ground mass with the naked eye, and the study of the thin section reveals little but that it is extremely siliceous. The quartz seems to be perfectly clear and often perfect in crystalline form, and the doubly terminated hexahedron predominates. There is little or no superficial weathering of the rock mass, though the entire rock shows great alteration, and is without doubt a product of metamorphic processes. Under the microscope the porphyritic nature of the rock is more clearly visible—whole and fractured quartzes set in a quartz-feldspar paste from which little can be determined. Spaces of dissolution are a prominent feature of the rock, occasionally giving a cellular structure, and the presence of pyrite and magnetite is everywhere noteworthy.

From the few sections at hand, none of which proved to be entirely satisfactory, little positive information could be gathered. It does not appear, however, that Mr. Santos's conception of the mass can be regarded as correct; careful search was made for the columnar structure he noted, but beyond a series of cross fractures which form a noticeable characteristic of the exposure, it is certain that he must have been misled. Similarly, there is not the slightest hint of sedimentary origin in any of the exposures or thin sections examined.

Mr. von Drasche's necessarily hasty observations, leading to the view that this mass is a lens of quartz embedded in the trachyte, are not substantiated by a more careful study of the structure of the region, and hence this view is regarded as improbable.

All the evidence at hand points to a contact zone of limited extent, produced by the Mancayan diorite being covered by a considerable flow of the "trachyte." Both microscopic and megascopic evidence show that the quartz porphyry is not original as such, and that but little of it, except the quartz, has existed unchanged since its formation.

Three analyses [1] of the quartz porphyry are given below:

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	0.22	0.11	0.00
Loss on ignition	1.24	2.70	3.18
Silica (SiO_2)	89.49	90.60	87.96
Alumina (Al_2O_3)	4.88	.07	3.75
Ferric oxide (Fe_2O_3)	4.24	3.15	3.89
Ferrous oxide (FeO)	.05	1.15	.69
Lime (CaO)	.04	.08	.08
Magnesia (MgO)	.32	.58	.23
Potassium oxide (K_2O)	.08	.16	.11
Sodium oxide (Na_2O)	.25	.70	.39
Total	100.81	99.30	100.28

[1] Analyses by L. A. Salinger, Bureau of Government Laboratories, Manila.

THE TRACHYTE.

Covering all to the eastward of a line from Mancayan to Suyoc, and apparently over a much greater general area, is a rock which Von Drasche classifies as a hornblende-sanidine-quartz-trachyte, and from lack of other than megascopic inspection for a guide, that name, or more simply quartz-trachyte, expresses the rock as nearly as may be.

It is a much-decomposed granular-to-porphyritic mass, which weathers to varicolored clay, giving an appearance to the soil which may not be mistaken. In all the field work no absolutely fresh specimen could be obtained and those collected have altered in the laboratory.

There is present a noticeable amount of quartz in clear, rounded, fracture grains and prominently in doubly terminated hexahedrons; feldspar in short, tabular crystals, much decomposed; clear sanidines with typical luster and twinning; a ferro-magnesian mineral, indeterminate as to amphibole or pyroxene, in somewhat noteworthy amount; occasional biotite; considerable magnetite. The placing of the feldspars in the general mass gives the typical orthophyric structure, as opposed to the more common trachytic structure; the proportion of ground mass varies locally, but in all cases it is subordinate to the phenocrysts, approaching a pronounced granitoid texture in cases.

Below are given several analyses [1] of the rock, made from imperfect field specimens. With no microscopic examination possible, and only the aid which the divergent and not representative analyses give, it appears that more exact determination may better be left to more detailed work in the Mancayan region. The name given by Von Drasche appears to be sufficiently definite for the purposes of this report and the rock will be so designated.

Analyses.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	1.58	1.84	3.88
Loss on ignition	4.82	7.04	2.23
Silica (SiO_2)	54.80	68.31	60.48
Alumina (Al_2O_3)	19.29	18.18	18.11
Ferric oxide (Fe_2O_3)	1.83	2.15	3.14
Ferrous oxide (FeO)	2.54	.37	1.67
Lime (CaO)	8.21	.24	4.94
Magnesia (MgO)	3.11	.25	2.12
Potassium oxide (K_2O)	2.50	.98	1.88
Sodium oxide (Na_2O)	1.55	None.	2.40
Total	100.23	99.86	100.30

[1] Analyses by L. A. Salinger, Bureau of Government Laboratories, Manila.

THE MINING BUREAU.

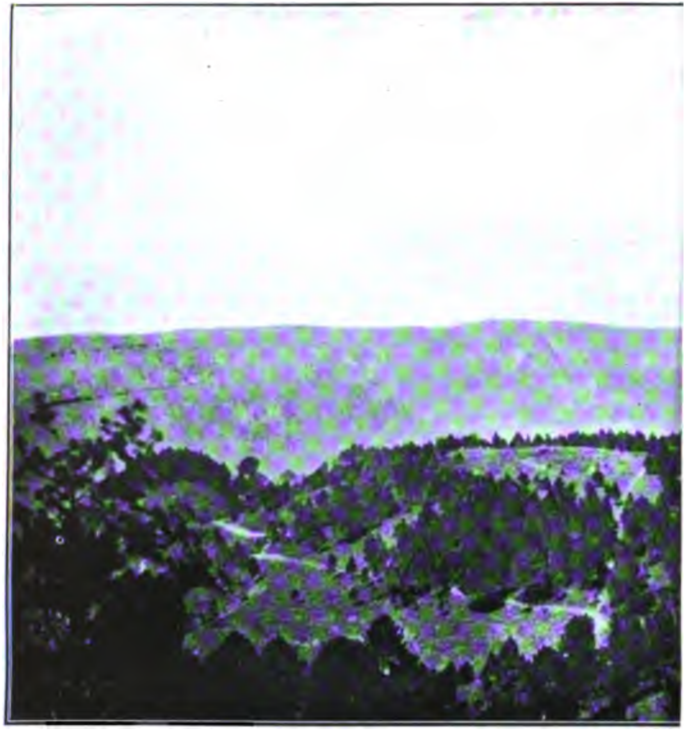


Photo by A. J. Eveland.

THE MINING BUREAU.

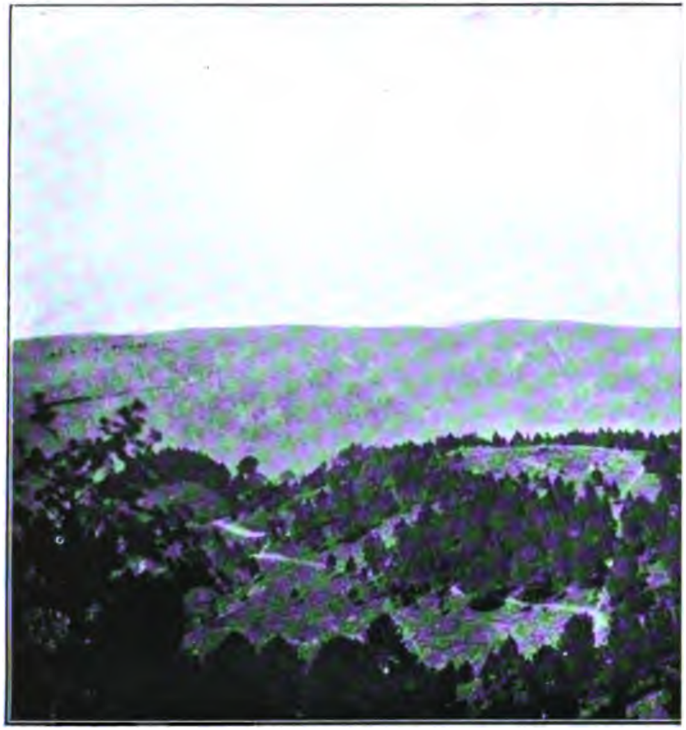


Photo by A. J. Eveland.

Photo by A. J. Eveland.

OLD NATIVE WORKINGS AT SUYOC.

CHAPTER VI.

ORE DEPOSITS.

MINERALOGY OF THE ORES.

GANGUE MINERALS.

Under the head of gangue minerals are included those most intimately connected with the metallic minerals of the lodes, and which form the matrix of the latter. The term is used in its commonest sense, to signify the constituents of the lode that occur in intimate connection with the mineral under exploitation, and as the ores of this district are of a prevailing type, no ambiguity will result.

Quartz.—Comp. SiO_2, oxide of silicon = oxygen 53.5, silicon 46.7 = 100. Massive or in hexagonal prisms terminated by rhombohedrons. Often in double six-sided pyramids. Generally white or colorless. Hardness = 7. Sp. gr., 26. Luster, vitreous, sometimes greasy. Transparent to opaque.

The quartz of this region shows essentially the same characteristics of vein quartz that occurs in most mining districts. There is present a comb-structure quartz showing "crustification," or banded-vein structure, having its origin in the filling of fissures either by growth in an open space or by slow expansion of a mere crack. The quartz of the Mancayan mines is hard, tough, compact, of a resinous luster, much shattered, and of a fine grain. The quartz from this locality is, from its observed nature, due almost entirely to secondary action of silicifying solutions. Replacement of other minerals and the filling of rock fractures have produced a quartzose mass, the bulk analysis of which shows a high per cent of silica. Such rock in thin sections under the microscope may reveal skeleton-like forms of crystals of other minerals, replaced entirely or partially by silica.

Almost without exception the vein-filling material of the region is quartz, the proportions of other minerals present being variable. There are, besides, occurrences of minerals other than quartz in that capacity which may be spoken of.

Barite.—Barytes. Comp. $BaSO_4$, barium sulphate, orthorhombric, commonly in tabular crystals, in divergent form, or massive. From its high specific gravity (4.5) it takes the name "heavy spar." Cleavage perfect in three directions. White. Transparent to opaque. Sometimes yellow, gray, brown, or red. Barite is less important as a vein material in this region, but its occurrence is noted.

Calcite.—Calc spar. Comp. $CaCO_3$, calcium carbonate = carbon dioxide 44, lime 56 = 100. Rhombohedral. Cleaves perfectly in three directions, producing rhombohedrons. Commonly in this form, or prisms, scalenohedrons, or massive. Color variable, where impure, generally white or colorless. Transparent to opaque.

Unimportant as a vein material, though occurring throughout the district. Found in abundance as a microscopic constituent of lode materials.

Kaolinite.—Kaolin. Comp. $H_4Al_2Si_2O_9$ or 2 H_2O. Al_2O_3. 2 SiO_2 = silica 46.5, alumina 39.5, water 14 = 100. Monoclinic. In scales or plates, and generally in fine white powder. Occurs as clay-like masses, compact, mealy, or friable. H. = 2–2.5. Sp. gr., 2.6.

This mineral occurs throughout the district, and especially in the Suyoc region, as a result of the decomposition of rock material, aluminous minerals, and feldspars. At Mancayan veins of several inches in thickness run through the upper trachyte; these are very pure kaolin, of a good white color. They crop out south of the village on the main trail.

Gypsum.—Comp. $CaSO_4$, 2 H_2O, hydrous calcium sulphate = sulphur trioxide 46.6, lime 32.5, water 20.9 = 100. Monoclinic, varieties selenite in transparent tabular crystals, to massive, often fibrous, cleavage on one plane eminent, giving foliated structure. H. = 1.5–2. Sp. gr., 2.3. Luster, subvitreous to shiny. Color usually white; varieties, where impure, colored. Transparent to opaque. The occurrence of gypsum at Suyoc is suggestive of recent volcanic activity. In the gorges of the Pacat Rivers and other drainage streams of Suyoc hill occur numerous veins of gypsum, often of considerable extent. These veins are of the fibrous variety, the widest observed giving a length of about 2 or 3 feet to the curved transverse fibers. Some of the rich values of that particular region were, it is claimed, taken from one of these veinlets.

ORE MINERALS.

This heading embraces the minerals of this district, which are generally mined for ores, or value of some nature, although it may be borne in mind that local conditions determine to a great extent just the heading that certain minerals come under. The minerals of this list, unless attention is called to it, have all a metallic luster.

Gold.—Comp. gold. Isometric, but rarely showing crystalline form. Usually in irregular particles, filiform dendritic shapes, "wire" gold. Thin plates, rounded edges, and flattened grain or scales. Cleavage none. Fracture hackly. Very malleable and ductile. H. = 2.5–3. Sp. gr., 15.6–19.3, 19.33 when pure. Luster, metallic. Opaque in ordinary masses.

In the Lepanto mining districts most of the attention has been directed to the free-gold workings.

At Suyoc, where visible gold is to be observed, the metal occurs in fine

Photo by A. J. Eveland.

OLD NATIVE WORKINGS ON QUIEN SABE VEIN, SUYOC.

Photo by A. J. Eveland.

ANCIENT SUYOC WORKINGS.

plates and grains in small quartz seams, in connection with sulphides of copper, zinc, and lead. The natives work only the free gold and have no knowledge of other values. Farther north the gold values seem to be more closely confined to iron pyrites, and less to the other sulphides. In Mancayan gold values are obtained from both the copper ores of the district and the quartzose vein matter of Mancayan and Tuboc.

Pyrite and marcasite.—Pyrites, "iron" pyrite, "white" iron. Comp. FeS_2, iron disulphide = sulphur 53.4, iron 46.6 = 100. Isometric, pyritohedral, cube and pyritohedron (pentagonal dodecahedron), octahedron, or combination of these, the common forms, sometimes striated. Frequently massive, and finely granular. Color, pale brass yellow to whitish. Luster, metallic. Opaque. H. = 6. Sp. gr., 5. The common sulphide of iron here, as generally in mining districts, is common in all of the ores of the region, and to a greater or less extent present in the rock masses in the vicinity of the ore deposits. In this region the pyrites occur alone, in quartzose veins, associated or not, as the case may be, with other sulphides, and in the Mancayan ore, closely connected with the sulpho-salts of copper which constitute the ore of that region. While, as has been before noted, the pyrite of Suyoc is not worked for gold by the natives, not enough samples of it have been taken to demonstrate that it carries no values. As noted before, it is as yet undetermined just what relationship the pyrite and the gold values have, but as this district opens up more information on the point will be obtained, it is presumed.

Galena or galenite.—Lead glance, "lead." Comp. PbS, lead sulphide = lead 86.6, sulphur 13.4 = 100. Isometric, cubes predominating. Perfect cubic cleavage. Massive, granular, or finely granular, occasionally fibrous. Color, lead gray. H. = 2.5–2.75. Sp. gr., 7.4–7.6. Luster, metallic. Opaque. Generally argentiferous.

Galena is, compared with other minerals, not prominent in this region. On the Suyoc area alone it is observed, and here in connection with other sulphides in small amounts in quartz veins. Outside of the Suyoc area the quantity of galena occurring is practically negligible, so far.

Sphalerite.—Zinc blend, blende, black jack, "zinc." Comp. ZnS, zinc sulphide = zinc 67, sulphur 33 = 100. Isometric, tetrahedral, commonly massive; cleavage granular to compact. Brittle. H. = 3.5–4. Sp. gr., 3.9–4.1. Luster, resinous. Color, commonly yellow to black. Transparent to translucent. Occurs in considerable amounts in the Suyoc area, in conjunction with sulphides of copper, lead, and iron.

Chalcocite.—Copper glance. Comp. Cu_2S = copper 79.8, sulphur 20.2 = 100. Orthorhombic crystals, pseudo-hexagonal, twinning. Massive granular to compact. Brittle. Luster, metallic. Color, lead gray, often tarnished blue or green. Opaque. H = 2.5–3. Sp. gr., 5.5–5.8. Occurs in the Mancayan area with other copper minerals.

Bornite.—Purple copper ore, peacock copper. Comp., a sulphide of

iron and copper, variable (Cu_3FeS_3 = sulphur 28.1, copper 55.5, iron 16.4 = 100). Isometric, cubic. Massive, granular or compact. Brittle. H. = 3. Sp. gr., 4.9–5.4. Luster, metallic. Color, copper red to brown, iridescent. Opaque.

Observed mineralogically, with other copper minerals of Mancayan.

Chalcopyrite.—Copper pyrite, yellow copper. Comp. $CuFeS_2$ = sulphur 35, copper 34.5, iron 30.5 = 100. Sulphide of iron and copper, variable, due to admixtures. Crystals commonly tetrahedral. Massive, compact. Brittle. H. = 3.5–4. Sp. gr., 4.1–4.3. Luster, metallic. Color, brass yellow, often tarnished. Opaque.

This is present in variable amounts throughout the district. Generally in quartz veins associated with other sulphides.

Tetrahedrite.—Gray copper. Comp. 4 Cu_2S, Sb_2S_3 = sulphur 23.1, antimony 24.8, copper 52.1 = 100. Composition variable. Sulphide of copper and antimony. Isometric, tetrahedral. Rather brittle. Luster, metallic. Color, flint gray to tin black. Opaque, translucent (red) in thin splinters. H. = 3.4. Sp. gr., 4.4–5.1. Arsenic and antimony are generally present and composition of this mineral is extremely variable. The high percentage of copper in this mineral (approximately 52 per cent), as well as its abundant occurrence in the mine of the Cantabro-Filipino Company at Mancayan, makes this one of the most important of the region. It is also found in the Suyoc area, on various claims of that region.

Enargite.—Comp. Cu_3AsS_4 or 3 Cu_2S, A_2S_5 = sulphur 32.6, arsenic 19.1, copper 48.3 = 100. Orthohombric, crystals usually small and striated. One perfect cleavage. Brittle. H. = 3. Sp. gr., 4.43–4.45. Luster, metallic. Color, grayish black to iron black. Opaque.

This mineral, as well as tetrahedrite and other copper-sulphur salts, constitutes the greater part of the large ore body of the Mancayan mine. Occurring with this is luzonite, composed essentially as enargite, but differing in crystallization.

Several analyses of the typical ore from the Mancayan mine are given below:

	I.	II.	III.	IV.	V.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble residue		49.19	55.93	66.72	30.10
Silica	47.06	45.91	45.31	64.53	23.40
Sulphur	24.44	20.36	15.40	12.98	23.58
Antimony (metallic)	5.12	None.	None.	None.	None.
Arsenic (metallic)	4.65	2.26	.43	1.80	.40
Iron (metallic)	1.84	14.25	8.98	8.96	11.13
Copper (metallic)	16.64	13.90	16.54	9.72	32.92
Lead (metallic)		None.	None.	None.	None.
Loss	.25				
Total	100	99.96	97.28	100.18	98.13
Gold (ounce)		0.23	0.16	0.08	0.04
Gold value, at $20.67		$4.75	$3.31	$1.65	$0.83

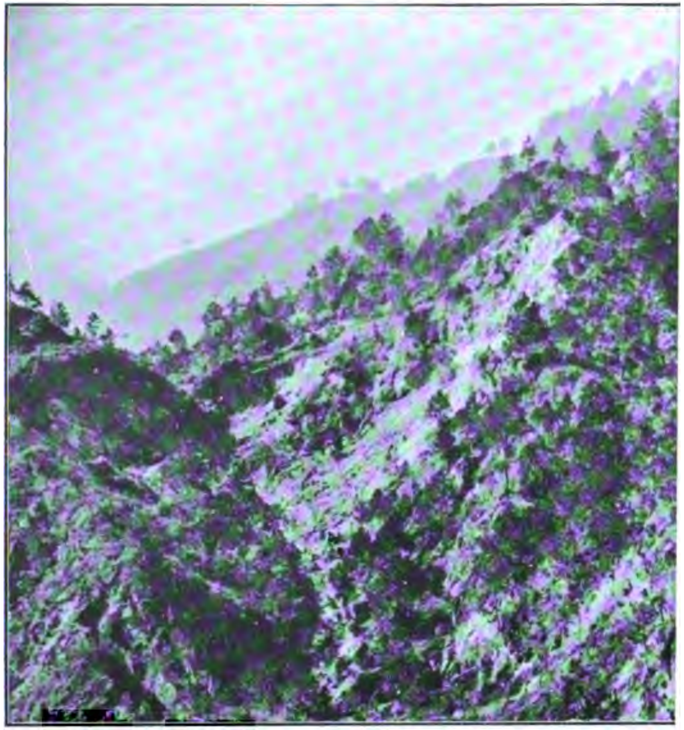


Photo by A. J. Eveland.

No. I is from Santos's Informe (p. 38) and is given as the mean composition of the different ore breasts of the native workings.

II is a piece of *ore* from the "Carmen" workings of the Santa Barbara mine, Mancayan, selected as typical.

III is a sample taken of the ore the natives (Igorots) use in their smelting, probably from different portions of the Mancayan mine.

IV is another sample taken as typical of the "Santa Barbara" ore.

V is a rounded bowlder of apparently almost pure copper mineral; to the glass it reveals only crystallized enargite, with some very slight amount of quartz and an occasional bunch of chalcocite.

It is not known by whom the analysis was made for Mr. Santos. The analyses numbered II to V, inclusive, are from the Bureau of Government Laboratories, Manila, to which work of this character is submitted.

Another specimen of ore was examined[1] mineralogically by Dr. W. E. Ford, of Yale University, with the following result:

The specimens show the characteristic crystals of enargite in the cavities. They are elongated parallel to the vertical axis and show their orthorhombic character by the shape of their cross section. For the most part the faces are not well developed, the prism zone showing the deep striations characteristic of the mineral. The blowpipe tests agree with those required by enargite.

The most prominent mineral of the specimens is a massive mineral which on a weathered surface has a dull-bronze color, but which on a fresh fracture shows a reddish-gray tone. No evidences of crystallization could be discovered. Its fracture is uneven. Its blowpipe and chemical reactions are identical with those of enargite; it decrepitates in the closed tube and gives sublimates of sulphur and arsenic sulphide; with nitric acid and ammonia it gives the deep-blue solution indicating copper. Its appearance and reactions agree with those described for the mineral luzonite.

It seems rather remarkable that none of the four analyses above quoted show any traces of antimony, as between the arsenical and antimoniacal sulpho-salts of copper there is a constant variation and transition, and rarely, if ever, is one known without the other. Santos gives 5.12 per cent of antimony, and it seems highly probable that this better represents the composition of the ore. The analyses, however, are quoted as reported.[2]

Of superficial decomposition products there is in this region but little trace; occasional bunches of iron and copper carbonates and sulphates are found, but only in limited quantities. The geology of the region, as will be shown later, precludes any oxidized croppings of any but occasional veinlets, and, except for scattered points and sections of the

[1] Courtesy of Prof. Joseph Barrell, Yale University. This analysis confirms that previously made by H. M. Ickis, of the Mining Bureau.

[2] A second examination of Nos. III and V, for the presence of antimony, gave 0.11 per cent and 0.06 per cent metallic antimony, respectively, a "trace" in Nos. I and IV.

underground workings of the old Mancayan mine, decomposition products are singularly lacking.

DISTRIBUTION AND RELATIONS OF VEINS.

Of the ore deposits in the Lepanto area, and in fact in northern Luzon, that of Mancayan has been most known and is most prominent. The occurrence there of copper ore has led to further search in the vicinity, and while the Mancayan deposit is at present far beyond any other locality in size and value, the future may develop more extended masses of ore here or in other localities.

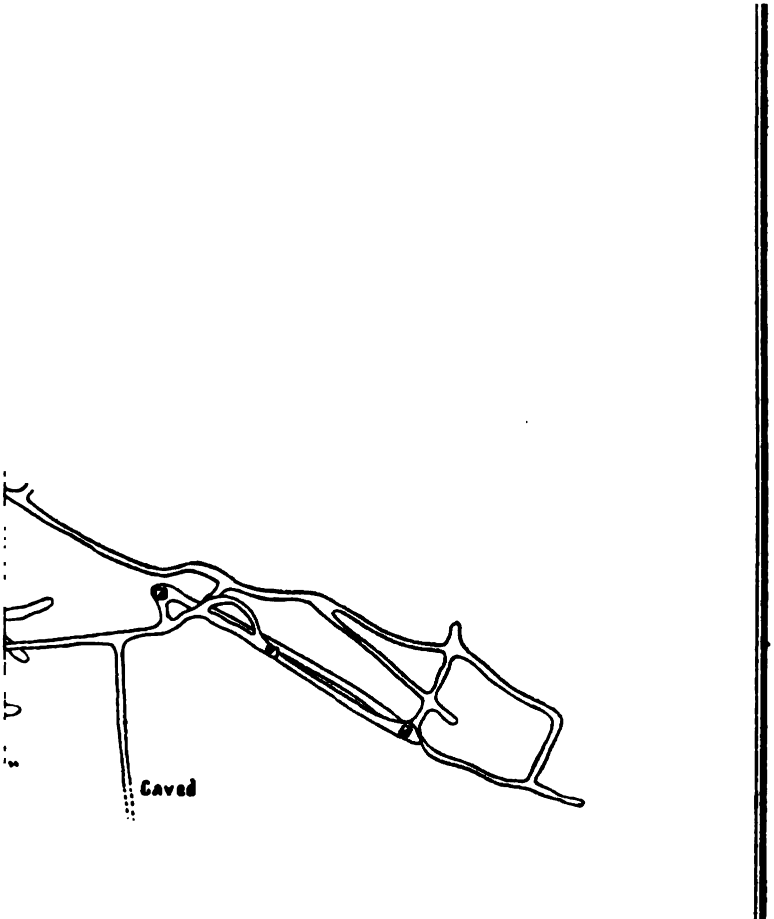
The Mancayan deposit has been uncovered for a long time by the Mangambang (Igorot, meaning "copper") River cutting a deep gorge diagonally across the southeast end of a quartzose mass bearing copper ores. At this place there is a nearly vertical wall of 100 or 200 feet, the strike of which, coinciding approximately with the course of the river, is northwest. From mining operations of past years there is a heavy talus and dump pile, and the face of the cliff is pierced by numerous tunnels, some of them mere dog holes, others cut with precision and good workmanship. Several systems of levels explore most of the ore body, the lowest one serving for the purpose of drainage. In the many years of operation of this mine several thousand feet of workings have been made and a considerable amount of ore extracted.

There is no indication of a regular form to the deposit, except that from a tunnel on the west side of the northern extension of the main deposit it is seen that the quartzose mass evidently dips 10° to 15° to the east, resting on the Mancayan diorite.

Much of the mine was flooded at the time of the visit, and without maps of the workings other than the one included in the report which was made of some of the principal galleries, it is only possible to draw general inferences as to the nature of the deposit.

The siliceous mass constituting the outcrop is apparently the same in character as the quartz porphyry described under "Rocks." At the Mancayan mine it loses its lithoidal nature and consists more or less entirely of quartz and ore minerals. The quartz has been previously shattered and jointed in every direction, and the cracks filled with either secondary quartz or ore minerals, notably pyrite, marcasite, chalcopyrite, and enargite. The mass at present is hard, compact, and firm, woven through with irregular veins of ore, with no system of distribution. The fissures, broadly speaking, have west-northwesterly and northeasterly directions, and of these the ones striking west-northwest seem to be most prominent as ore carriers.

The fissures would suggest contraction types due to cooling of an igneous effusion, dehydration of a mass, or some similar phenomenon, rather than those produced by dynamic causes. The fracturing has no



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other pronounced direction than that noted, and even this appears more or less forced.

This fracturing seems not to be confined entirely to the ore body, but is a characteristic of much of the surrounding rock mass. There is apparently no profound fissuring or faulting in the locality, and as yet no evidence is available that other displacement than the local fractures of the Mancayan ore deposit exist.

The "veins" formed by the recementation of the quartzose mass by silica and metallic sulphides vary from finger-breadth cracks to one body (the largest opened) over 20 feet across, of lens shape, of limited depth and length. There is no continuity of these singly, and the workings therefore follow the Spanish method and are crooked and narrow, following rich seams.

Unfortunately for a thorough investigation, many of the galleries were flooded or caved, and the exact relation of the deposit could not be made out. One important observation is worth recording: The lowest tunnel, a regular and large gallery, driven for drainage, has in its present length, and in the side drifts, which are under the greater part of the other workings, no signs of ore—in decided contrast to the rich values of a few feet above; the explanation of this is not certain.

From the nature of the ore masses, it is evident that the enargite and chalcopyrite and some quartz have been formed around the earlier particles of pyrite and quartz. The enargite is well crystallized and undoubtedly later than the pyrite, inclosing the latter.

From the few assays made it would seem to be indicated that the values in gold come from the pyrite, as the assay of a bowlder of almost pure enargite from the mine gives but little value, those samples of which a portion was pyrite showing values up to $5 a ton in addition to their copper content.

In the immediate vicinity of Mancayan there are but few openings of any depth or length, and only negative results are obtained from these. The western slope of the hill is predominantly an outcrop of the quartz porphyry, copper bearing to a mile north of Mancayan mine in variable amounts, and so far as shown decreasing in content to the north. No shafts deeper than a few feet have been sunk over the deposit, or in its vicinity, and these reveal only the soft material derived from the weathering of the trachyte. The tunnels on the east slope of the hill are driven in Mancayan diorite, and when the party left the field were still in that material, so that, except from the Mancayan mine proper, nothing is known of the extent of the deposit.

On the north slopes of Mancayan hill crop two exposures of the same vein, a 2-foot fissure of quartz, heavily loaded with pyrite and some chalcopyrite, the strike of which is east and west. No exploration has been made of this.

South of Mancayan, just west of Tuboc, conditions similar to those of the Mancayan outcrops prevail. There is there a standing face, 150 feet in height, of the same quartzose mass, but the rich ore seems entirely lacking, and the tunnels driven into it to the west so far have not shown other than promising indications.

At Cayan large slides and workings indicate that formerly values were sought, and the quartz-mass outcrops are of a slightly different character. The rock is more cellular in structure and is impregnated with pyrite only. Gold values obtain, and it is stated by reliable authority that these ores were mixed with the Mancayan ores in the blast furnace, on account of their siliceous and pyritiferous character. As the ground is well covered with Spanish pertenencias, no prospecting work has been done of late years.

The ores of the district alter perceptibly as more southerly points are reached, and in addition to the change noted at Cayan, Suyoc and its surrounding territory offer a decided contrast to the Mancayan type.

North of Suyoc, between it and Cayan, the ore-bearing veins are well-defined quartz leads, of small width, generally not over 3 feet, with a content of lead, zinc, and iron sulphides. No general direction of these veins can be traced, but it is the opinion of several of the miners in the district that those corresponding more closely to an east and west strike give the greater values. The length of the veins is limited and no depth beyond a few feet has yet been explored. The "country rock" is here the Mancayan diorite, much decomposed and altered, and the presence of veins of gypsum up to widths of several feet is noteworthy. Several acres of this territory have been cut down rapidly by the combined efforts of the rainy season and the Igorots in their workings, and an enormous slide results, the material being washed down the narrow gorge to join the Maanse River. Every rainy season the Igorots impound this water at the end of long ditches, "boom" away the overlying muck, and obtain a considerable amount of free gold by crushing and panning the vein material. It may be noted in this connection that an assay of the material the Igorot discarded as of no value yielded 0.20 ounce of gold per ton, a value of $4.03. Numerous pockets have been found in this slide that were surprisingly rich, it being stated that 20 *pounds* of metal was taken from one such occurrence a few years ago.

The Suyoc hill deposits, as yet only partially prospected, have the same general character—quartz veins of no great width, carrying metallic sulphides, and a considerable gold content, most of it in a free state. In two notable instances, on the "Eureka" claim of Mr. C. A. Pettit and the "Quien Sabe" of Mr. Albert Wright, copper sulphides form a great proportion of the vein filling, and these and the other properties are being developed by tunnels.

All along Suyoc hill, west and south of the Abra River, are large eroded

Photo by A. J. Eveland.

MANCAYAN COPPER MINE, SOUTHERLY ASPECT.

Photo by A. J. Eveland.

COPPER MINES, MANCAYAN.

Photo by A. J. Eveland.

COPPER MINES, MANCAYAN.

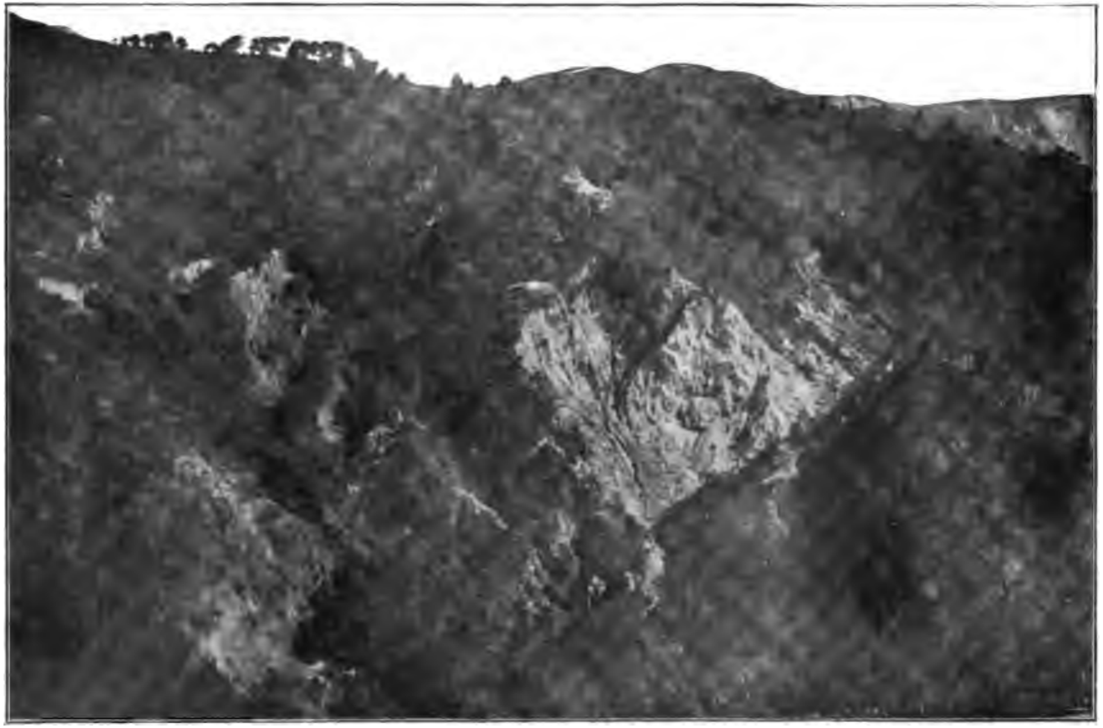

Photo by A. J. Eveland.

CAYAN WORKINGS. SUYOC HILL AND THE PALIDAN SLIDE, SUYOC, IN RIGHT BACKGROUND.

Photo by A. J. Eveland.

WESTERN PORTION OF PALIDAN SLIDE.

cirques, owing their existence primarily to ancient workings, and all of the same general type.

In view of the fact that the entire region, with the exception of the one ore body of the Mancayan mine, is in an early stage of development, it is impracticable to treat the ore deposits in detail. It seems to be fairly conclusive, however, that the general type of vein in the district is a narrow quartz lead, carrying metallic sulphides, in some cases of copper, and generally with gold associated in a free state. These veins are in the Mancayan diorite which underlies the entire district. With the advent of the trachyte flow, metamorphic changes have taken place, and the nature of the country rock altered to a considerable degree.

It would be rash to enter into a discussion of the genesis of the deposits on the meager data available, and in consequence such will be left to more complete reports that will follow detailed geological work upon a topographic base.

The former attempts to explain the Mancayan deposit have been given and objections to each have been found, and as a mere tentative hypothesis may be suggested a genesis of these ores as yet not considered, that will be determined when further development work is done. It is entirely within the grounds of probability, and not in conflict with any geological evidence so far at hand, to presume that, before the advent of the trachyte flow, ore deposits had been formed in the Mancayan diorite of a type similar to those at Suyoc—quartz veins carrying metallic sulphides and gold values. With the covering of the diorite and its veins by an igneous flow, chemical action was given an added impetus. The trachyte, easily decomposed and altered, was metamorphosed at its contact with the diorite to a hard, flinty, siliceous quartz porphyry, quartz replacing most of the other constituents of the rock. In its cooling and subsequent contraction fissures and crevices were formed, aided possibly by dynamic action, such as shattering shocks, which are a feature of the Islands. The heat of the overlying trachyte furnished a motive power for the process of vein deposition, and the heated waters, assumed to be rising, filled the cavities and cracks with silica and ore minerals obtained from lower or surrounding sources. Enargite is a prominent mineral among those formed by secondary action, and investigation shows that it has been formed later than the other minerals; so that the evidence points to a secondary enrichment of certain portions of the contact, notably at Mancayan, with copper minerals obtained from other sources. Deposition has taken place in all possible directions, leaving the irregular mass of veins of the Mancayan mine.

There is nothing in this hypothesis to preclude the possibility of other similar deposits in other portions of the area, or, indeed, of one or more veins, as yet not opened, in a more or less vertical position, which may occur under the trachyte, in the diorite, and which afforded a main trunk

On the road work in a large proportion of the provinces Filipinos of various races have been employed, and with a single exception reports have been very satisfactory. Mr. N. M. Holmes, after three years of observation, as chief engineer of the Benguet road, condemns the Filipino laborer from every point of view. It is believed, however, that there were factors in that period which no longer have to be considered, as during the completion of the same enterprise, under the supervision of Maj. L. W. V. Kennon, United States Army, as chief engineer, reports as to the native labor employed were decidedly favorable.

The Atlantic, Gulf and Pacific Company, using up to 1,000 men, have, according to the report of Mr. H. Krusi, the vice-president, met with unqualified success. The Cavite Navy-Yard, also using large numbers of Filipino laborers, has, according to the report of Captain Couden, United States Navy, been equally successful in meeting the problem. The Manila Electric Railway and Lighting Company, in its construction and operation of about 60 kilometers of line, have used Filipinos from the start with like success. In all these works effort has been made to provide for the wants of the Filipino, to make life as comfortable as possible under the conditions, and to learn and apply the proper supervision.

Of more pertinence to this report is the unqualified statement of all at present engaged in mining operations that Filipino labor not only may be endured but that it bears comparison with other races. In Benguet, Masbate, Camarines, and other districts Filipinos are being used; in other districts native labor has been employed in the past; and all with goods results. The keynote seems to be successful and competent supervision, with as much careful study of native characteristics as would be given to any other little-known problem.

That the *proper* use of native labor reduces considerably the costs involved can not be denied, and this factor can not be neglected.

As has been stated previously, however, the problem in Lepanto has conditions peculiar to itself, which should be carefully considered. It may be said in the beginning that dependable labor, certain in supply and quality, can not be obtained locally. There is, it is true, a large population, most of them used to labor, to draw upon for limited or occasional demands, but that local supply will meet the demand of extensive mining operations, steadily and with the requisite intelligence, seems extremely doubtful, at least. This applies to the regular forms of more or less skilled labor which mining operations depend upon for their very existence.

Employment of white foremen and white skilled labor will be found necessary. The employment of Chinese and Japanese has met with a certain measure of success in other parts of the Islands, and the recent importations of East Indians, Tartars, and other races into South Africa to relieve labor troubles there is suggestive of possibilities.

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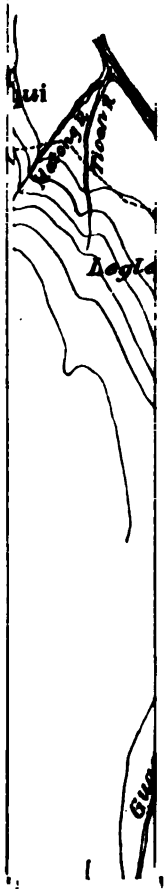

Transportation at present, with but slight exception in the way of native porters or "cargadores," may be marked nil. Transport in both directions, supplies in and product out, must be considered. The present lines of travel are horse and foot trails, and the distance to the coast (about 40 miles) makes packing excessively expensive. Direct railroad projects seem unfeasible, and a railroad down the Abra Valley, with its terminus at Vigan, has been considered as questionable. The nearest light in that direction would seem to be an examination of the route between Lepanto and the capital of Benguet Province to the south, Baguio. There has been completed a superb wagon road from the northern terminus of the railroad, Dagupan, to Baguio, and the railroad continuation, probably under electric motive power, is assured within a short time. Mancayan and Baguio are about on the same level at an altitude of 5,000 feet, and the existence of a route along the mountain ridge between the two is very probable. It is expected that the present field work of the Bureau will throw light on this suggestion, and at all events the question of routes and costs can not be abandoned so lightly. It will take careful examination of known routes, and equally careful search over newer routes, before assurance may be had as to either result. It is not believed, however, that the difficulty is insurmountable.

The solution of these two most important problems, will practically eliminate the remaining obstacles. There is in the district water in sufficient quantities for considerable power, and by transmission from a small distance the whole power of the Abra River may be utilized, in a combination of hydraulic and electric methods.

It is doubtful if steam could be furnished at the mines for any considerable amount of call upon it. Former smelting operations and lack of preservation have removed the timber from the whole valley of the Abra, and while it is believed that plenty of wood fuel is within a reasonable distance, it would take careful calculation before any design of power plants could be considered.

We have, then, the consideration of a district whose prospects certainlv appear of a favorable nature. There are numerous obstacles to be overcome, but all, of them, it is believed, may be handled if the one vital problem, of the presence of the ore, is settled. Given the ore, large and valuable enough, and the remainder of the problem becomes one of adaptation and engineering.

The old Mancayan mine was, without doubt, an extraordinarily rich deposit and the quantity of ore still remaining is worthy of examination. The ore dump, of huge size, contains ore that was then discarded, but under new conditions represents in itself a small mine of fair grade. The old smelter sites and slag dumps are rich with such material as slags containing as high as 32 per cent of copper, and further underground work may reveal more ore bodies. So far as the work already done goes,